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FINAL REPORT 2

INSTRUMENT CONSTRAINTS AND INTERFACE SPECIFICATIONS

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EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY (EOS)

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER

IN RESPONSE TO
CONTRACT NAS5-20519

TRW SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA 90278

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1. INTRODUCTION

This report contains the equipment specifications for the thematic mapper and high resolution pointable imager; a section summarizing interface requirements intended for the use of the systems contractor; and a contractual procurement package that would be used by TRW Systems to contract for the payload instruments.

The equipment specifications are detailed and are intended to serve as part of a total procurement package. The justifications for the individual specifications are given in Reports 1 and 3.

The interface requirements are extracted from the equipment specifications and are intended as a summary to be used by the system and spacecraft designer.

The contractual procurement section contains subsections on general requirements, a statement of work, a mission assurance subsection and a TRW subcontract management plan. A total procurement package would also contain an equipment specification and a section on environmental requirements. As the launch vehicle is not yet selected, environmental requirements are not specified.

2. THEMATIC MAPPER EQUIPMENT SPECIFICATION

2.1 SCOPE

This specification establishes the requirements for the performance, design, fabrication, test, and quality assurance provisions for a thematic mapper (TM), sometimes referred to as the instrument. The unit is one scientific instrument to be flown on the Earth Observatory Satellite (EOS).

2.2 APPLICABLE DOCUMENTS

The following documents of the exact issue specified form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced and other detail contents of this specification, the detail requirements herein will be considered superseding.

2.2.1 Specifications

Military

MIL-P-116E	Preservation, Methods of

TRW

TBD	Environmental Specification Qualification, Qualification/Acceptance and Acceptance Test Requirements for EOS Components
TBD	EOS Electromagnetic Interference Requirements Specification
2A014	Connector, Rectangular, Multi-Pin, MIL-C-24308 Type

2.2.2 Standards

Military

MIL-STD-129E	Marking for Shipping and Storage
MIL-STD-130D	Identification Marking of U.S. Military Property
MIL-STD-143B	Military Standards and Specifications, Order of Precedence for the Selection of

MIL-STD-794C Appendix D	Parts and Equipment, Procedure for Packaging and Packing of
MIL-STD-889	Dissimilar Metals
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment Facilities

NASA

NHB5300.4(3A)	Requirements for Soldering Electrical Connections

DRAWINGS

TRW

C - TBD	Thematic Mapper, EOS, Outline and Mounting Drawing

2.2.3 Other Documents

TRW

Section 5.3 this document	Mission Assurance Requirements for Subcontractors — EOS

2.3 REQUIREMENTS

The unit described by all the requirements of this section will pass all of the examinations, analyses, and tests specified in Section 2.4.

2.3.1 General Description

The thematic mapper scans the ground area below the spacecraft, collecting radiation in each of seven spectral bands, and develops analog signals whose magnitude is dependent on the radiation intensity in each band. These signals along with appropriate synchronization and housekeeping signals are processed by a government-furnished multiplexer and A/D electronics unit.

2.3.1.1 Spacecraft Orbit Details

The satellite is three-axis stabilized in an orbit that is sun synchronous and circular, with an orbit inclination of 99 degrees. The design altitude is 717 kilometers and the north to south equatorial crossing time is 11:00 a.m. local time.

2.3.2 Characteristics

The following subparagraphs define the performance and the physical characteristics as well as the requirements for reliability, maintainability, safety, environment, transportability, and storage.

2.3.2.1 Performance

The instrument will have the following performance characteristics.

2.3.2.1.1 Spatial Coverage

The instantaneous field of view (IFOV) of each detector is swept in a direction cross track to the ground path of the satellite. Contiguous coverage in the track direction is generated by appropriately timing successive cross track scans as the satellite advances in its ground track path. The scanning system for the thematic mapper may be either image plane, object plane, or a combination of both.

2.3.2.1.1.1 Alignment Reference

An alignment cube will be mounted to the front face of the thematic mapper (Figure 2-1). All mirror surfaces on the cube will be orthogonal to within 1.0 arc-seconds. Normals to these surfaces will define the instruments X_r, Y_r, and Z_r axes. The X_r axis will nominally be aligned on the spacecraft with the velocity vector. The Z_r axis will nominally be aligned on the spacecraft with the Nadir vector.

2.3.2.1.1.2 Scanned Field of View

The scanned field of view is the solid angle resulting from motion of the IFOV by the scanning mechanism. The width of this scanned field will at least be 14.70 degrees as measured in the Y_r - Z_r plane. The field of view of the central detector of the band 1 array will be the reference IFOV.

2.3.2.1.1.3 Scan Line Synchronization

A scan line synchronization signal reference will be provided with each line of video in each spectral band and will also be provided on a separate output line with TTL output characteristics. The low-to-high transition in this sync signal will occur when the center of the IFOV, for the central detector of the band 1 array, is nominally 7.35 degrees from the X_r - Z_r plane, as measured in the Y_r - Z_r plane. The short-term

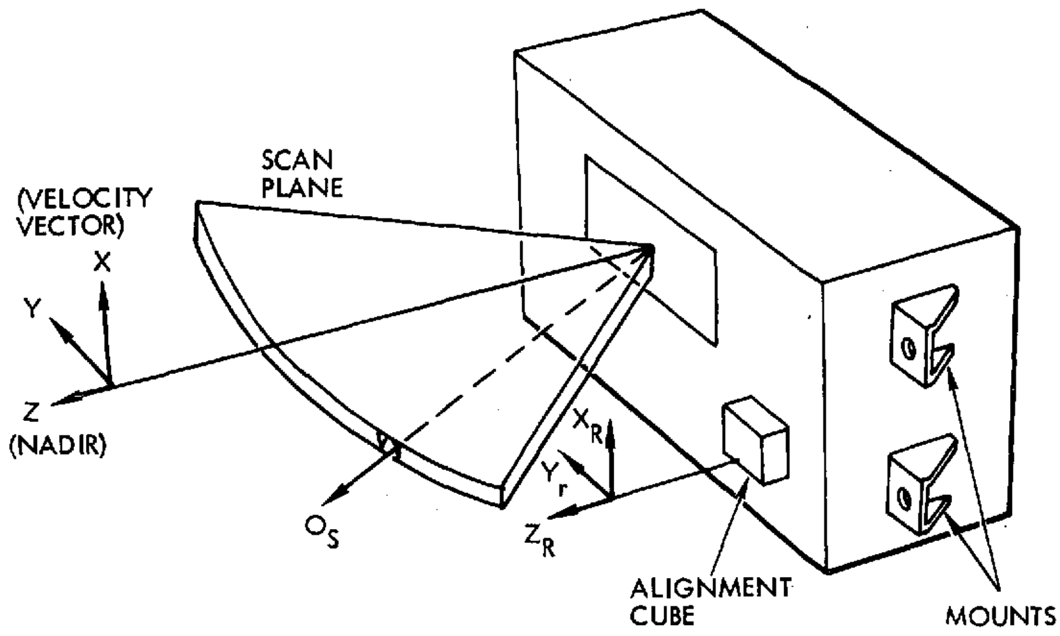

Figure 2-1. Thematic Mapper Coordinate Frame

stability (<30 seconds) of this sync position will be ±1 arc-second 1σ. The long-term stability (>30 seconds) will be ±10 arc-seconds 1σ. The timing between successive scan syncs will be consistent with the requirement to assure that the final reconstructed image is maintained in line-to-line alignment to better than 3.0 meters (0.1 IFOV).

2.3.2.1.1.4 Scan Linearity and Stability

Define scan vector (O_s) as the vector at the center of the reference IFOV. Define scan time (t_r) as the time measured from the start of the line sync. For the same scan time, the orientation of scan vector O_s, relative to the X_r, Y_r, Z_r frame, will be repeatable to ±1 arc-second and ±10 arc-seconds, respectively, for short (<30 seconds) and long (>30 seconds) observation periods. If the long-term stability cannot be met, then other instrument signals, such as the encoder output should be provided. Their quality must allow ground correction of the data, consistent with the requirement to provide better than 3.0 meter registration of the IFOC's within the scanned field. The angular rates of vector O_s will be constant within ±1 percent 1σ over the total scanned field of view. The rates should be alterable by ground command to accommodate an altitude range of 717 ± 10 kilometers.

2.3.2.1.1.5 Band-to-Band Registration

Points imaged simultaneously in separate bands will be registered to each other within ±10 percent of an IFOV in the along and cross-track directions. Constant time delays between the data from one band and another band may be accommodated.

2.3.2.1.2 Spatial Resolution

Using thematic mapper information, it is desired to ultimately generate maps at a nominal resolution of 30 meters for each of 6 color bands, and 120 meters for the 7th band. In order to ensure this resolution, the following performance constraints are imposed.

2.3.2.1.2.1 Modulation Transfer Function

The spatial resolution of bands 1 through 6 will be adequate to provide peak-to-peak modulation transfer of at least 0.5 for simulated subsatellite target sizes corresponding to 42 μradian per half cycle of spatial frequency. Similarly, for band 7, a modulation transfer of at least 0.5 is required for simulated subsatellite target sizes corresponding to 168 μradian per half cycle of spatial frequency.

2.3.2.1.2.2 Suppression of Stray Radiation

Suitable optical baffles will be used in the telescope to reduce the effect of stray radiation on the performance of the radiometer. The measurement of a minimum brightness target element in any channel will be changed by less than 2 percent of full scale by the presence of a maximum albedo scene of angular extent 1 degree, as close as three elemental fields of view from the minimum brightness element.

Sun shields may be used on the radiometer if the contractor requires them to supplement the internal optical baffles in suppressing unwanted radiation. If sun shields are used they will be limited to the same envelope constraints as the radiometer. The sun shields are to be mounted as part of the radiometer.

2.3.2.1.3 Spectral Coverage

The relative spectral response of the seven spectral bands are indicated in Table 2-1. This response characteristic applies to the total instrument, including optics, filters, detectors, etc.

Table 2-1. Spectral Band Characteristics

Band Number	1	2	3	4	5	6	7
Cut-On Wavelength (μM)	0.5 ± 0.01	0.6 ± 0.01	0.7 ± 0.01	0.8 ± 0.01	1.55 ± 0.02	2.08 ± 0.02	10.4 ± 0.1
Cut-Off Wavelength (μM)	0.6 ± 0.01	0.7 ± 0.01	0.8 ± 0.01	1.1 ± 0.01	1.75 ± 0.02	2.35 ± 0.02	12.6 ± 0.1
Edge Slopes(1) (μM)	0.02	0.02	0.03	0.03	0.05	0.05	0.1
Spectral Flatness(2) (percent)	75	75	75	75	75	75	75
Spurious Transmittance(3) (percent)	5	5	5	5	5	5	5

NOTES:

(1) Edge slope is defined as the wavelength interval between 5 percent absolute transmittance and 70 percent of peak transmittance. The above are maximum values.

(2) Spectral flatness is defined as the percent of the wavelength range (bandwidth) over which the transmittance does not vary by more than 20 percent of the peak transmittance.

(3) Spurious transmittance is the ratio of the integrated solar energy transmitted outside the bandpass to that within the bandpass.

2.3.2.1.4 Sensitivity

2.3.2.1.4.1 Bands 1 through 6 Sensitivity

Bands 1 through 6 will produce a minimum low spatial frequency signal-to-noise ratio (SNR), defined as peak-to-peak signal voltage to RMS noise voltage, in accordance with the following table:

Band	Spectral Band (Micrometers)	Minimum Input Radiance watts/m^2-ster)	SNR Minimum
1	0.5 to 0.6	2.2	10
2	0.6 to 0.7	1.9	7
3	0.7 to 0.8	1.6	5
4	0.8 to 1.1	3.0	5
5	1.55 to 1.75	0.8	5
6	2.1 to 2.35	0.3	5

The output analog signals will have negligible coherent or noncoherent noise (1/3 of peak-to-peak wideband noise maximum, as observed with a wave meter).

2.3.2.1.4.2 Band 7 Sensitivity

The sensitivity of band 7 is measured in terms of the noise equivalent temperature difference (NETD). The NETD is defined for purposes of this specification as the change in scene temperature about a given temperature which will cause a change in signal peak-to-peak amplitude equal to the RMS noise. The maximum NETD for this band for an extended scene temperature of 300°K is 0.5°K.

	Spectral Band (Micrometers)	Minimum Input Radiance (x 10^{-5} watts/cm^2-ster)	NETD
Band 7	10.4 to 12.6	200 (300°K) (nominal)	0.5°K

2.3.2.1.4.3 Polarization-Dependent Sensitivity

The optical design will ensure that the polarization of the instrument does not exceed 0.05. The polarization is defined as the ratio of the difference between maximum and minimum output to the sum of the maximum and minimum output obtained when the plane of the incoming linearly polarized radiation is rotated through 180 degrees.

2.3.2.1.5 Dynamic Range

Each detector channel will include a variable gain linear amplifier in order to better accommodate different scene lighting conditions, and to provide a means of in-flight trimming of gains of one channel relative to the others.

2.3.2.1.5.1 Input Radiance Range at Minimum Gain

The thematic mapper will be capable of providing calibrated radiance measurements of scenes having radiance values from noise level to those input levels indicated in the following table.

Band	Spectral Band (Micrometers)	Maximum Input Radiance (watts/m^2 ster)
1	0.5 to 0.6	36.3
2	0.6 to 0.7	29.7
3	0.7 to 0.8	23.1
4	0.8 to 1.1	36.3
5	1.55 to 1.75	6.6
6	2.1 to 2.35	3.9
7	10.4 to 12.6	26.5

2.3.2.1.5.2 Gain Range

The linear gain in each individual detector channel will be selectable, by ground command, to one of eight discrete levels.

Gain State	Relative Gain	Gain State	Relative Gain
0	1.0	4	1.46
1	1.1	5	1.61
2	1.21	6	1.77
3	1.33	7	1.95

2.3.2.1.6 Radiometric Accuracy

In order to maintain radiometric measurement accuracy for the total mission duration, both internal and external reference sources will be used to periodically calibrate the system at discrete input radiance levels. Calibration at intermediate levels is inferred by using an internal multi-level voltage generator to determine the nonlinear characteristics of the electronics. These calibration references will either be rendered as calibration data for ground computer correction or used internal to the instrument to maintain constant overall gain.

2.3.2.1.6.1 Accuracy

The end-to-end transfer function (output signal versus input radiance) for each detector channel will be known to an absolute radiometric accuracy of ±10 percent of full-scale radiance. The relative gain of one detector channel with respect to another will be known to within ±1 percent of full scale radiance.

2.3.2.1.6.2 Internal Radiometric Calibration

Separate video signal outputs will be generated for each detector channel. Each video signal, during a line scan, will include the radiometric signal while scanning the earth scene, and also while viewing internal calibration targets.

For bands 1 through 6, one high level, one low level and one dark reference light source will be scanned. The high and low level radiance levels will be near the extremes of the dynamic radiance range defined in Section 2.3.2.1.5.1. Any light source parameters such as current or temperature, necessary to define the source brightness to an accuracy consistent with the end-to-end accuracy specified in Section 2.3.2.1.6.1 will be included in the housekeeping data.

For band 7, two blackbody calibration targets will be provided. The surface of the target area will be designed to simulate a blackbody radiator. One target will be at a temperature of $320^{\circ} \pm 1^{\circ}K$. The other target may be the instrument case or other low level source. The temperature of the calibration targets will be measured to the best accuracy possible using redundant platinum resistance temperature detectors appropriately arrayed to adequately define the temperature of the target. The temperature instrumentation allows for $0.1^{\circ}K$ precision in the probable operating temperature range. Signals which are representative of the calibration source temperatures will be added to the composite analog video train in each channel following the line sync signal.

2.3.2.1.6.3 Voltage Calibration Signal

The voltage calibration signal will consist of a ramp calibration.

- The ramp calibration signal will consist of the output of a D/A generator which increases one step per scan.
- A ramp will be generated every 1024 scans of the radiometer. The ramp voltage will vary from 0 to full scale volts and will have a precision of 10 bits.
- The ramp calibration signal will be added to the video signal train during the temperature calibration region of the scan.

2.3.2.2 Physical

2.3.2.2.1 Weight

The maximum weight of the entire TM subsystem (optics, electronics, cooler, insulation, etc.) will not exceed 182 kg (400 pounds), not including 6 kg for a G.F.E.'d signal processor.

2.3.2.2.2 Size, Shape, Center of Gravity, and Mounting

The mounting of the TM will be via three points located at the sides normal to the long axis (Figure 2-1). Two opposing mounts define an axis through the cg. The third mount counters rotation about this axis. The maximum envelope size will not exceed 183 x 97 x 102 cm (cross-track axis x nadir x track axis). Optics, momentum compensation, electronics, and insulation are to be confined to this volume. Calibration targets may be mounted outside this volume but must be confined within the projection towards nadir of the maximum length and width dimensions given above. The orientation of the cooler will be 135 degrees from nadir (anti-sun side). Any projection of the cooler, i.e., cooler cone, outside the given envelope must be detachable from the TM to allow instrument replacement while in orbit. Center of gravity will be as close as possible to the middle of the instrument and its mounting points to avoid long cantilevered arms. The TM will accommodate, within the given volume, the following modules.

Module	Size (in.)	Weight (lb)	Power (watts)
MODS	3.5 x 6 x 8	7	12
DIU	1 x 6 x 8	1.2	2.8

2.3.2.3 Interface Requirements

2.3.2.3.1 Electrical Interface

The anticipated electrical input signal and output signal parameters, the power requirements, and the electrical performance characteristics of the radiometer are given in this section. All specified characteristics will be within tolerance over the lifetime of the equipment despite the combined effects of signal impedance, and power supply variations (within specified tolerances, but taken at worst-case values), radiation degradation, and environmental increments.

2.3.2.3.1.1 Input Signals

The presence of any, all, or none of the input signals applied in any sequence will not damage the equipment, reduce its life expectancy or cause any malfunction, either when the radiometer is powered or when it is not.

8.0 MHz Timing Signal Input. The characteristics of the 8.0 MHz timing signal are as follows:

- Signal type: constant frequency symmetrical trapezoidal wave.
- Frequency: 8.0 MHz
- Frequency stability: ±0.003 percent over a short-term period of 24 hours.
- The signal to noise ratio of the timing signal will be 20 dB peak-to-peak signal to RMS noise or greater. The noise peaks will not exceed one fourth of the clock signal amplitude.
- Signal levels will be TTL compatible.

  High Level: $5.0 \begin{smallmatrix}+0.5 \\ -2.6\end{smallmatrix}$ volts

  Low Level: $0.0 \begin{smallmatrix}+0.25 \\ -0.0\end{smallmatrix}$ volts

All digital signals used in the TM will be derived from this clock signal.

Command Signals. Two 16-bit command words are available that will be updated every 120 seconds. One word will contain all of the on/off commands for separate portions of the instrument (heater, scan motor, momentum compensation, external calibrate, etc.). The other word contains magnitude information (focus position, scan rate, mode select, etc.). One data-clock (1 MHz) signal, two data enable lines, and two data lines comprise the command interface. The enable line(s) is high for 16 data clock periods during data transfer. All signals will be TTL compatible.

Power Subsystem. The power to the TM will be unregulated +28 vdc (negative side grounded). Power ground bus to signal ground bus isolation, except at the common tie point external to the instrument, will be provided in the TM by the use of DC-DC converters or DC-AC inverters with the required input/output load characteristics. The basic power bus characteristics are given below:

Bus voltage	+28 ±7 volts
Source impedance	0.25 ohms (0 to 5 kHz)
Ripple and noise	500 mv p-p (5 Hz to 100 kHz)
Transients due to –	
Load changes	±1 volt for 100 ms
Failure modes	Bus may drop to +20 volts or rise to +39 volts for 100 ms

The power consumption of the instrument will not exceed 100 watts. Heater power will not exceed 50 watts additional.

2.3.2.3.1.2 Output Signals

General. The data from each band of the TM will be interfaced with the digital signal processor (not part of this contract) in analog fashion. In addition to these analog signals, the line synchronization signals will also be routed to the signal processor on a separate buffer isolated line. Short circuit protection of all outputs will be provided The instrument will operate within specification, except for the shorted output while that output is shorted, and the entire radiometer will operate within specification after removal of a temporary short.

The digital signal processor/TM interfaces will be designed to take place within the TM.

Radiometer Signal Output.

- Positive type analog signal with the DC level for bands 1 through 6 restored each scan line when the radiometer views an appropriate black target.

- The signal amplitude will be from 0 to 2.0 volts. At gain state 0, (Paragraph 2.3.2.1.5.2) the gain will be set so that +1.9 ± 0.05 volts corresponds to the maximum radiance input (Paragraph 2.3.2.1.5.1). The gain setting allows for an adjustable maximum radiance input by changing a fixed resistor in an amplifier with a minimum of disassembly of the instrument.

  The signals from the radiometer when viewing the high level calibration source will be measured when the radiometer is maintained at its nominal temperature.

- The low frequency cut-off will be such that the signal droop is less than 0.39 percent of the full signal amplitude during the time of one scan line.

- The drift from scan line to scan line will not exceed one 0.5 percent of the full scale amplitude.

- Scanning a step function input in radiance will produce a maximum overshoot of 2 percent of the final amplitude with less than one cycle of the ringing frequency and maximum duration of one microsecond.

- The output impedance will be 100 ohms or less. The output capacitance will be less than 20 pf. The output will be capable of driving capacitances of up to 100 pf in the signal processor.

Sync Pulse Signal Output. The scan line to scan line jitter, including noise, of the synchronization pulse will be equivalent to less than 0.1 of an IFOV. The jitter of the synchronization pulse between any two scan lines within a 20-minute period will be within one IFOV. The output will be TTL compatible.

Electronic Reticles. The TM will be able to provide to the signal processor electronic reticle signals Each signal will be within the range 0 to 2.0 volts. The output impedance will be 100 ohms or less and the output capacitance will be less than 20 pf. The output will be capable of driving capacitances of up to 100 pf in the signal processor.

Telemetry Outputs. Enough telemetry points will be designed for evaluation of the status and performance and to troubleshoot the radiomete in the event of difficulties. It will be possible to obtain telemetry regarding all radiometer temperatures whether the radiometer electronics is on or off. It will be possible to short any telemetry output to the power bus, or to ground, or to other telemetry outputs without damaging the telemetry circuitry or affecting in any manner whatsoever the performance of the instrument.

- Four 8-bit digital telemetry words are available for transmittal of command verification, and digital housekeeping data. One data-clock (1 MHz) signal, four data enable lines, and four data lines comprise the digital telemetry interface. The enable line(s) is high for 8 data clock periods during data transfer. All signals shall be TTL compatible.

- As many as 50 analog signals, relating instrument internal temperatures, voltages and currents, can be accommodated by the telemetry subsystem. Signals will be sampled every 2 seconds with 8-bit resolution. The voltage range will be 0 to 2.0 volts. Output impedance will be less than 1000 ohms.

Test Points. Test points will be provided for the TM to the extent necessary to determine the status of the instrument as well as metering points by which alignment of the instrument may be implemented.

The test points may be used during testing. Short circuit protection of these points will be provided. The TM will operate within specifications in the event any test point is shorted to power bus, ground, or another test point, and upon removal of the short. All test points will be provided through a separate keyed connector(s).

As a minimum, the location of test points will be as follows:

- Band 1 video signals
- Band 2 video signals
- Band 3 video signals
- Band 4 video signals
- Band 5 video signals
- Band 6 video signals
- Band 7 video signals
- Temperature calibration signals

- Sync pulse signal after phasing with 1.0 MHz clock
- Mid-scan pulse
- Externally introduced signal to cause DC restoration to both visible and IR bands
- Voltage calibration signal.

2.3.2.3.2 <u>Thermal Interface</u>

The radiometer will be designed to operate over a temperature range of 20 ± 10°C. The instrument will be thermally isolated from the spacecraft. Therefore, the instrument will contain an active thermal control system, and will remove the heat from the TM electronics, including the G.F.E.'d signal processor by radiative means No more than 1 watt of heat may be transferred to the structure at the TM mounting points. The temperature of the spacecraft structure will range between 10°C and 30°C. Continuous instrument operation during the total orbit should be assumed in the thermal design.

2.3.2.3.2.1 <u>Detector Cooler</u>

The contractor's thermal design will include provisions for a passive detector cooler. The cooler will be mounted 135 degrees from nadir on the anti-sun side of the vehicle and will look into a hemisphere except for the 60 degree cone subtended by the earth, and must be shaded from earth radiation. The cooler must be designed so that any projection, i.e., cooler cone, outside the maximum TM envelope must be detachable to allow instrument resupply while in orbit, with due regard to the necessary thermal interfaces.

2.3.2.3.3 <u>Mechanical Interface</u>

The mechanical interface will be as defined in TRW drawing <u>TBS</u>

2.3.2.3.3.1 <u>Allowable Experiment Disturbance Levels</u>

Periodic momentum with frequencies exceeding 0.1 Hz (cut-off of control system) will not produce a resultant rigid spacecraft motion having a peak value greater than 5 μradians for a spacecraft having a moment of inertia of 1000 slug-ft^2.

Momentum variations with frequencies within the control system passband ($0 \leq f < 0.1$ Hz) will not exceed a total momentum level of 0.2 ft-lb-sec.

2.3.2.4 Reliability

The reliability requirements are defined in paragraph 5.3.5.

2.3.2.4.1 Reliability Prediction

The instrument will have a probability of successfully surviving launch, boost, injection and 2 years in orbit of at least 0.900 under operating and nonoperating usage and environmental conditions as specified herein.

2.3.2.4.2 Redundancy

There is no specified redundancy requirement except for requirements deemed necessary by the manufacturer to ensure meeting the survivability requirement (paragraph 2.2.4.1).

2.3.2.4.3 Failure Reporting

A failure is defined as any out of specification condition. These conditions will be reported as specified in paragraph 5.3.7.

2.3.2.5 Maintainability

The instrument will be designed to give consideration to accessibility and interchangeability.

2.3.2.5.1 Service and Access

The instrument will be designed to permit its removal and replacement with a minimum of disturbance to associated or adjacent equipment.

2.3.2.6 Safety

Safety will be designed into the equipment to the maximum degree possible, consistent with the performance requirement of this specification and the safety requirements as defined in paragraph 5.3.8.

2.3.2.6.1 Fail Safe

A single part failure will not adversely affect any other spacecraft system or unit.

2.3.2.7 Environment

The unit will be designed to withstand the environmental conditions encountered during assembly, test shipping, handling and storage, prelaunch, launch/ascent and orbital operations in accordance with the environmental conditions specified in EV2-TBD, with the exception of meteoroids and earth thermal radiation. Appropriate packaging and/or protection devices external to the unit should be used for protection during shipping, handling, storage, and prelaunch operations.

2.3.2.8 Design Life

The instrument will be capable of performing as specified for not less than 2 years under all natural combinations of the operating environmental conditions including wear, environmental degradations, and expendables. This period is in addition to the storage requirements of paragraph 2.3.2.10.

2.3.2.9 Transportability/Transportation

The instrument will be designed to be transported by common carrier with a minimum of protection. Special packaging will be used as necessary to assure that transportation methods do not impose design penalties.

2.3.2.10 Storage

The instrument will be capable of being stored for a minimum of 3 years without requiring repair, maintenance, or retesting at the end of storage.

2.3.3 Design and Construction Standards

The design and construction of the instrument will be in accordance with the following requirements.

2.3.3.1 Parts, Materials and Processes

The selection of parts, materials, and processes will be in accordance with paragraph 5.3.6. The reliability level of electronic parts used for the construction of the instrument will be as specified in paragraph 5.3.6. All parts, materials, and processes used by TRW subcontractors must have TRW approval prior to use.

2.3.3.2 Selection of Specifications and Standards

Selection of specifications and standards for necessary commodities and services not specified herein will be in accordance with the provisions of MIL-STD-143.

2.3.3.3 Drawings

Drawings will be prepared in accordance with paragraph 5.3.4.

2.3.3.4 General

2.3.3.4.1 Thermal Design

The instrument will be designed so that all internal sources of heat have adequate heat flow paths to the radiative coolers. All environmental requirements of this specification and of EV2-TBD will be considered in the thermal design. The instrument will withstand the specified temperature extremes without performance degradation.

2.3.3.4.2 Finish

Protective coatings will be applied to the unit for corrosion protection and for thermal control. The coating will withstand the environmental conditions of EV2-TBD without any damage that would affect operational performance and will meet the electrical bonding requirements of EV2-TBD.

2.3.3.4.3 Magnetic Requirements

The unit will be capable of operating in a DC magnetic field as specified in EV2-TBD.

2.3.3.5 Electrical

The unit will meet the requirements as specified in EV2-TBD. The cable run for the instrument will be at least 3 feet and not exceed 4 feet. The electrical interface and connector type will be as described in TRW drawing TBD.

High Voltage (HV).

- Design philosophy will be in accordance with the requirement that any HV system will not be damaged and operate normal through critical altitude.
- Any component not encapsulated having an applied voltage of 100 volts must be well vented.

- No hollow core components may be used in any HV section.
- The total scanner package including all compartments must have a leak down time constant in a vacuum of a few seconds.
- Wax treated components will not be used.
- Shielding of any HV power supply will be provided if RF fields produced by HV supply can damage adjacent components.
- HV power supplies will be located in the proximity of loads.
- HV cabling will be shielded.
- No demonstration of corona survival is planned.

2.3.3.6 Mechanical

2.3.3.6.1 Lubrication

The mechanisms which require lubrication will be given special consideration in their design, testing, processing, and handling. Rotating and translating mechanisms will be driven with torque/force margins 6 dB over the maximum torque/force expected. This will assure continued operation of the system as degradation or loss of lubrication occurs.

The lubricant's rate of evaporation must be considered both from the standpoint of loss of lubrication and contamination of optical components. The scanner system design will reflect the sensitivity of the lubrication problem and verification testing performed at a component level where a critical situation exists.

2.3.3.7 Nuclear

2.3.3.7.1 Radioactivity Control

The unit will be designed to minimize all possible radioactive sources. Isotopes of radium, thorium, uranium, and their radioactive daughter products are to be avoided. Examples of components which contain these materials are:

- Magnesium – thorium alloys used in structural material
- Luminous paint
- Depleted uranium weights and counterbalances
- Radioactive fuel gauges.

In addition, neutron radiography will not be used on flight hardware.

Any radioactive source used in the unit must have prior approval from TRW.

2.3.3.8 Fungus Resistance

Materials that are nutrients for fungus will not be used when their use can be avoided. Where used and not hermetically sealed, they will be treated with a suitable fungicidal agent that meets the outgassing requirements of paragraph 5.3.6.

2.3 3.9 Dissimilar Metals

Unless suitably protected against electrolytic corrosion, dissimilar metals will not be used in contact with each other. Dissimilar metals will be as defined in MIL-STD-889.

2.3.3.10 Contamination/Cleanliness Control

Contamination/cleanliness requirements of the assembled unit will be in accordance with paragraph 5.3.6.

2.3.3.11 Coordinate Systems

The instrument reference coordinate system is identified in Figure 2-1.

2.3.3.12 Interchangeability and Replaceability

Each unit will be directly interchangeable in form, fit and function with other units of the same part number. The performance characteristics and dimensions of each unit will be uniform to permit equipment interchange with a minimum of adjustment and recalibration.

2.3 3.13 Identification and Marking

The unit will be identified in accordance with the provisions of MIL-STD-130. Marking will include but not be limited to the following:

- Part number
- Serial number
- Item name
- Project name (EOS)

- Actual weight to be determined to an accuracy of ±0.01 pound. Weight to be specified in pounds.
- Contract number
- Manufacturer's name
- Date of manufacture.

2.3.3.14 Workmanship

Workmanship quality will be such that the reliability inherent in design is not degraded. Workmanship acceptability of manufacturing processes will be assured to requirements depicted in applicable drawings, specifications and standards, and as further delineated by quality operating instructions, process specifications, and workmanship standards.

2.3.3.14.1 Soldering Requirements

Soldering of electrical connections will be performed in accordance with NHB5300.4(3A).

2.3.3.15 Human Performance/Human Engineering

MIL-STD-1472 will be used as general guidance for man/machine interfaces.

2.3.4 Other Requirements

2.3.4.1 Optical Materials Radiation Resistance

Care will be exercised in the selection of optical materials to insure against degradation of unit performance beyond specified tolerances as a result of the prolonged exposure (714 km orbital altitude, 99 orbital inclination) to ultraviolet radiation and trapped proton and electron fluxes as specified in Table 2 of EV2-TBD.

2.4 VERIFICATION

2.4.1 Responsibility for Inspection and Test

The supplier is responsible for compliance to all test requirements as specified herein.

2.4.1.1 Quality Assurance Provisions

The unit will be fabricated and inspected in accordance with the quality assurance requirements as defined in paragraph 5.3.7.

2.4.2 Verification Methods

Verification methods shall include similarity, analysis, inspection, and test.

2.4.3 Development

The extent of development verification/testing will be recommended by the supplier except as specifically required by the Statement of Work. Development verification is the basis of verifying the feasibility of the design approach and providing confidence in the ability of the unit to pass qualification/acceptance verification. All development test data will be available for TRW review.

2.4.4 Classification of Verification

The verification of the unit will be classified as follows:

- Qualification/Acceptance (See Section 2.4.5)
- Acceptance Verification (See Section 2.4.6)

2.4.5 Qualification/Acceptance Verification

The following subparagraphs specify the requirements for and the methods used to verify that the design and performance requirements of Section 2.3 will be satisfied.

2.4.5.1 Similarity

Not applicable.

2.4.5.2 Inspection

The following requirements of Section 2.3 will be verified by an inspection of the equipment and/or review of design and fabrication data.

Paragraph	Requirement
2.3.2.2.1	Weight
2.3.2.2.2	Size, Shape, Center of Gravity and Mass
2.3.2.3.1	Electrical Interface
2.3.2.3.3	Mechanical Interface
2.3.2.5	Maintainability
2.3.2.6	Safety

2.3.2.6.1	Fail Safe
2.3.2.9	Transportability/Transportation
2.3.3.1	Parts, Materials and Processes
2.3.3.2	Selection of Specifications and Standards
2.3.3.3	Drawings
2.3.3.4.2	Finish
2.3.3.5	Electrical
2.3.3.7.1	Radioactivity Control
2.3.3.8	Fungus Resistance
2.3.3.9	Dissimilar Metals
2.3.3.10	Contamination/Cleanliness Control
2.3.3.13	Identification and Marking
2.3.3.14	Workmanship

Paragraph	Requirement
2.3.3.14.1	Soldering Requirements
2.3.3.15	Human Performance/Human Engineering

2.4.5.3 Analyses

The following requirements of Section 2.3 will be verified by analytical data.

Paragraph	Requirement
2.3.2.1.1	Spatial Coverage
2.3.2.1.1.1	Alignment Reference
2.3.2.1.1.2	Scanned Field of View
2.3.2.1.1.3	Scan Line Synchronization
2.3.2.1.1.4	Scan Linearity and Stability
2.3.2.1.1.5	Registration of Elemental Fields of View
2.3.2.1.2	Spatial Resolution
2.3.2.1.2.1	Modulation Transfer Function
2.3.2.1.2.2	Suppressing of Stray Radiation
2.3.2.1.3	Spectral Coverage
2.3.2.1.4	Sensitivity
2.3.2.1.5	Dynamic Range
2.3.2.1.6	Radiometric Accuracy
2.3.2.3.1.2	Output Signals

2.3.2.3.2	Thermal Interface
2.3.2.3.3.1	Allowable Experiment Disturbance Levels
2.3.2.4	Reliability
2.3.2.8	Design Life
2.3.3.4.1	Thermal Design
2.3.3.4.3	Magnetic Requirements
2.3.3.6.1	Lubrication
2.3.11	Coordinate System
2.3.12	Interchangeability and Replaceability
2.3.4.1	Optical Materials Radiation Resistance

2.4.5.4 Demonstrations

Not Applicable.

2.4.5.5 Tests

The following requirements of Section 2.3 will be verified by qualification/acceptance testing.

Paragraph	Requirement
2.3.2.1.1	Spatial Coverage
2.3.2.1.1.1	Alignment Reference
2.3.2.1.1.2	Scanned Field of View
2.3.2.1.1.3	Scan Line Synchronization
2.3.2.1.1.4	Scan Linearity and Stability
2.3.2.1.1.5	Registration of Elemental Field of View
2.3.2.1.2	Spatial Resolution
2.3.2.1.2.1	Modulation Transfer Function
2.3.2.1.2.2	Suppression of Stray Radiation
2.3.2.1.3	Spectral Coverage
2.3.2.1.4	Sensitivity
2.3.2.1.5	Dynamic Range
2.3.2.1.6	Radiometric Accuracy
2.3.2.3.1.2	Output Signals
2.3.2.7	Environment

2.4.5.6 Test Sample

One unit which has passed all acceptance inspections and tests will be used for qualification.

2.4.5.7 Qualification/Acceptance Sequence

Qualification/acceptance inspection and test consists of these examinations and tests in the following sequence:

- Pre-environmental inspection of product
- Pre-environmental functionals
- Random vibration
- Abbreivated functionals
- Shock
- Abbreivated functionals
- Thermal vacuum
- Post-environmental functionals
- Post-environmental inspection of product

2.4.5.8 Environmental Testing

Qualification/acceptance environmental tests listed in paragraph 2.4.5.7 will be performed as specified in EV2-TBD.

2.4.5.9 Electromagnetic Compatibility Testing

EMC testing will be performed in accordance with EV2-TBD.

2 4.5.10 Test Report

Following completion of qualification/acceptance tests, a test report will be prepared evaluating results of the tests.

2.4.5.11 Qualification/Acceptance Test Methods

2.4.5.11.1 Pre-Environmental Inspection

Prior to qualification/acceptance tests, the unit will be examined for compliance to the inspection requirements of paragraph 2.4.5.2.

2.4.5.11.2 Pre-Environmental Functional Tests

Verification that the equipment performs as specified herein will be achieved by the completion of the functional tests which include, as a minimum, testing of the requirements specified in paragraph 2.4.5.5.

2.4.5.11.3 Vibration

The random vibration exposures will be performed as specified in EV2-TBD. During the exposures, mating connections will be installed on all electrical connectors. The unit will be non-operating during exposures.

2.4.5.11.4 Abbreivated Functional Tests

After completion of vibration and shock exposures, tests will be performed to verify the following performance requirements:

Paragraph	Requirement
2.3.2.1.1.1	Scanned Field of View
2.3.2.1.1.6	Scanner Alignment
2.3.2.1.4	Sensitivity

2.4.5.11.5 Shock

During exposures, mating connectors will be installed and the unit will be non-operating.

2.4.5.11.6 Qualification Thermal Vacuum

Tests to verify the following functional requirements will be performed near the end of the soak period at both the high operational temperature and the low operational temperature during each cycle.

Paragraph	Requirement
2.3.2.1.1.2	Scanned Field of View
2.3.2.1.1.3	Scan Line Synchronization
2.3.2.1.4	Sensitivity

2.4.5.11.7 Post-Environmental Functional Tests

After all environmental exposures have been completed, tests will be performed to verify all the performance requirements listed in paragraph 2.4.5.5.

2.4.5.11.8 Post-Environmental Inspection

The unit will be inspected by visual examination or measurement to verify the following requirements:

Paragraph	Requirement
2.3.2.2.2	Size, Shape Center of Gravity and Mass
2.3.2.3.3	Mechanical Interface
2.3.3.4.2	Finish
2.3.3.14	Workmanship

2.4.5.12 Test Conditions

Unless otherwise specified for specific tests listed under Test Methods, qualification/acceptance inspection and tests will be conducted in accordance with the conditions and tolerances specified herein.

2.4.5.12.1 Standard Test Conditions

All examinations and tests will be conducted under the conditions specified in EV2-TBD, EV2-TBD, and this specification.

2.4.5.12.2 Equipment Accuracy

The accuracy of the measurement equipment will be accomplished by using secondary standards traceable to the National Bureau of Standards.

2.4.5.12.3 Test Tolerances

Except as specifically noted in the Test Methods, the maximum allowable tolerances (excluding measuring equipment errors) for test conditions and measurement will be as specified in EV2-TBD and as follows:

- Voltage or current measurements – DC: ±0.5 percent
- Sensor angle settings: ±30 arc-seconds

2.4.5.12.4 Temperature Changes

Changes from one specified temperature to another will be accomplished as specified in EV2-TBD.

2.4.5.12.5 Equipment Alignment

The alignment tolerances between the test equipment axes and the instrument axes will be as necessary to achieve the test objectives. These tolerances will be determined by the subcontractor subject to TRW approval.

2.4.5.12.6 Radiation Source

The radiation source used during the functional tests described in this document and its calibration must be approved by TRW Systems. This source will have uniformity, repeatability, and measurable radiometric accuracy consistent with the instrument performance requirements specified in Section 2.3.

The compliance of the illumination source to the above requirements must be demonstrated prior to initiation of tests. This may be done by subjecting the source to such tests as are necessary to measure its performance as defined in this specification. These tests may be performed by a qualified independent testing organization or as an alternate, the tests may be performed by the vendor and witnessed by TRW Systems prior to the performance tests.

2.4.5.13 Failure Criteria

The unit will exhibit no failure, malfunction, or out-of-tolerance performance degradation as a result of the examinations and tests specified. Any such failure, malfunction, or out-of-tolerance condition will be cause for rejection.

2.4.5.14 Rejection and Retest

If a failure, malfunction, or out-of-tolerance performance degradation occurs during or after a test, testing will be discontinued, or as otherwise directed by TRW, until the failure, malfunction, or out-of-tolerance condition (including design defects) is corrected. The pertinent test procedure will be repeated, as approved by TRW, until completed successfully. If the corrective action substantially affects the significance of results of previously completed tests, such tests will also be repeated.

2.4.6 Acceptance Verification

The following subparagraphs specify the requirements for and the methods used to verify that the requirements in Section 2.3 will be satisfied.

2.4.6.1 Inspection

The following requirements of Section 2.3 will be verified by an inspection of the equipment and/or review of design and fabrication data.

Paragraph	Requirement
2.3.2.2.1	Weight
2.3.2.2.2	Site, Shape, Center of Gravity, and Mass
2.3.2.3.1	Electrical Interface
2.3.2.3.3	Mechanical Interface
2.3.3.4.2	Finish
2.3.3.5	Electrical
2.3.3.13	Identification and Marking
2.3.3.14	Workmanship
2.3.3.14.1	Soldering Requirements

2.3.6.2 Analyses

The following requirements of Section 2.3 will be verified by review of analytical data.

Paragraph	Requirement
2.3.2.4.3	Failure Reporting

2.4.6.3 Tests

The following requirements of Section 2.3 will be verified by qualification/acceptance testing.

Paragraph	Requirement
2.3.2.1.1	Spatial Coverage
2.3.2.1.1.1	Alignment Reference
2.3.2.1.1.2	Scanned Field of View
2.3.2.1.1.3	Scan Line Synchronization
2.3.2.1.1.4	Scan Linearity and Stability
2.3.2.1.1.5	Registration of Elemental Fields of View
2.3.2.1.2	Spatial Resolution
2.3.2.1.2.1	Modulation Transfer Function
2.3.2.1.2.2	Suppression of Stray Radiation
2.3.2.1.3	Spectral Coverage

2.3.2.1.4	Sensitivity
2.3.2.1.5	Dynamic Range
2.3.2.1.6	Radiometric Accuracy
2.3.2.3.1.2	Output Signals
2.3.2.7	Environment

2.4.6.5 Test Sample

Each production unit will be acceptance tested.

2.4.6.6 Acceptance Sequence

Acceptance inspection and test consists of these examinations and tests in the following sequence:

- Pre-environmental inspection of product
- Pre-environmental functionals
- Random vibration
- Abbreviated functionals
- Thermal cycle
- Post-environmental functionals
- Post-environmental inspection of product

2.4.6.7 Environmental Testing

Acceptance environmental tests listed in paragraph 2.4.6.6 will be performed as specified in EV2-TBD.

2.4.6.8 Electromagnetic Compatibility Testing

EMC testing is not performed during acceptance testing.

2.4.6.9 Test Report

Following completion of the acceptance tests, a test report will be prepared evaluating results of the tests.

2.4.6.10 Acceptance Test Conditions

All test conditions will be in accordance with EV2-TBD and paragraph 2.4.5.12 of this specification.

2.4.6.11 Acceptance Test Methods

2.4.6.11.1 <u>Pre-Environmental Inspection</u>

Prior to acceptance test, the unit will have been examined for compliance to the inspection requirements of paragraph 2.4.6.1.

2.4.6.11.2 <u>Pre-Environmental Functional Tests</u>

Verification that the equipment performs as specified herein will be achieved by the completion of the functional tests which include, as a minimum, testing of the requirements specified in paragraph 2.4.6.3.

2.4.6.11.3 <u>Vibration</u>

The random vibration exposures will be performed as specified in EV2-TBD. During the exposures, mating connectors will be installed on all electrical connectors. The unit will be nonoperating during exposures.

2.4.6.11.4 <u>Abbreviated Functional Tests</u>

After completion of vibration exposures, tests will be performed to verify the following performance requirements:

Paragraph	Title
2.3.2.1.11	Scanned Field of View
2.3.2.1.1.6	Scanner Alignment
2.3.2.1.4	Sensitivity

2.4.6.11.5 <u>Acceptance Thermal Cycle</u>

Tests to verify the following functional requirements will be performed near the end of the soak period at both the high and low operational temperature during each cycle:

Paragraph	Title
2.3.2.1.1.1	Scanned Field of View
2.3.2.1.1.3	Scan Line Synchronization
2.3.2.1.4	Sensitivity

2.4.6.11.6 <u>Post-Environmental Functional Tests</u>

After all environmental exposures have been completed, tests will be performed to verify all the performance requirements listed in paragraph 2.4.5.5.

2.4.6.11.7 Post-Environmental Inspection

The unit will be inspected by visual examination or measurement to verify the following requirements:

Paragraph	Title
2.3.2.2.2	Size, Shape, Center of Gravity and Mass
2.3.2.3.3	Mechanical Interface
2.3.3.4.2	Finish
2.3.3.14	Workmanship

2.4.6.12 Failure Criteria

The unit will exhibit no failure, malfunction, or out-of-tolerance performance degradation as a result of the examinations and tests specified.. Any such failure, malfunction, or out-of-tolerance performance degradation will be cause for rejection.

2.4.6.13 Rejection and Retest

If a failure, malfunction, or out-of-tolerance performance degradation occurs during or after a test, testing will be discontinued, or as otherwise directed by TRW, until the failure, malfunction, or out-of-tolerance condition (including design defects) is corrected. The pertinent test procedure will be repeated, as approved by TRW, until completed successfully. If the corrective action substantially affects the significance of results of previously completed tests, such tests will also be repeated.

2.5 PREPARATION FOR DELIVERY

2.5.1 Method of Preservation and Packaging

2.5.1.1 General

The unit will be preserved and packaged in accordance with requirements specified herein.

2.5.1.1.1 Contamination/Cleanliness

Contamination/cleanliness requirements of the assembled unit will be to the requirements of paragraph 5.3.6.

2.5.1.1.2 Drying

The unit will be dried by any process of MIL-P-116 that will not be injurious.

2.5.1.1.3 Preservation

Unless otherwise specified, all units will be preserved and packaged in accordance with the applicable procedures of MIL-P-116.

2.5.1.1.4 Attaching Parts

When attaching parts, such as nuts, bolts, washers, etc., accompany a basic unit, they will be preserved, bagged, appropriately identified and attached to or adjacent of the fitting for which intended.

2.5.1.1.5 Electrical Connectors

Electrical connectors will be capped with protective dust caps. The caps will be a friction fitting type or threaded type which do not require tape or a mechanical device to secure.

2.5.1.1.6 Critical Surfaces

External machine surfaces and mounting surfaces will be protected by using mounting pads. Materials used for mounting pads will not cause commodity deterioration.

2.5.1.1.7 Wrapping

The unit will be wrapped in an anti-static polyethylene film material, minimum thickness being 4 mil. The wrap will be secured using appropriate tape or tie.

2.5.2 Levels of Preservation and Packaging

Unless otherwise specified, Level C applies to this unit.

2.5.2.1 Requirements

The level of preservation and packaging is Level A for all equipment designated as a spare unit, and Level C for all equipment designated for immediate use on the spacecraft, or in support of the spacecraft.

2.5.2.2 Level A

The unit will be preserved and packaged in accordance with the applicable method of MIL-P-116. Appendix D of MIL-STD-794 will be used to select an appropriate preservation method for Level A.

2.5.2.2.1 Special Requirements

Preservation and packaging selected for Level A will be capable of satisfying the following requirements:

Storage time:	3 years
Humidity:	70 percent of less

2.5.2.3 Level C

The unit will be preserved and packaged in a manner which will afford protection against corrosion, contamination, deterioration, and damage during shipment from the supply source to the first receiving activity for immediate use or use in support of the spacecraft.

2.5.3 Levels of Packing

Unless otherwise specified, Level C applies to this unit.

2.5.3.1 Requirements

The levels of packing will be either Level B for spare units or Level C for immediate use units.

2.5.3.2 Level B

The unit, packaged as specified in Sections 2.5.1.1 and 2.5.2.2, will be packed in exterior shipping containers of the domestic type in accordance with the applicable specification in Tables II or III of MIL-STD-794.

2.5.3.2.1 Special Requirements

The packed unit will be capable of withstanding the environments specified in EV2-TBD.

2.5.3.3 Level C

The unit will be packed in a manner that will provide against damage and contamination during shipment from the supply source to the first receiving activity for immediate use. Shipping containers will be in accordance with rail, air, or motor common carrier rules and regulations as published in their applicable classification guides.

2.5.4 Packaging Design Requirements

Correlation with the unit design, environmental and transportability criteria in Section 3.3 will be a prerequisite of package design.

2.5.5 Marking

All unit, intermediate and shipping containers will be marked in accordance with MIL-STD-129. Other special marking as specified in the subcontract will be applied.

2.5.6 Required Documentation

All required data, i.e., test reports, shipping invoices, etc., will be attached to the exterior surface of the shipping container. Attachment shall be in such manner to preclude loss of these data during handling and shipment.

3. HIGH RESOLUTION POINTABLE IMAGER EQUIPMENT SPECIFICATION

3.1 SCOPE

This specification establishes the requirements for the performance, design, fabrication, test, and quality assurance provisions for a high resolution pointable imager (HRPI), sometimes referred to as the instrument. The unit is one scientific instrument to be flown on the Earth Observatory Satellite (EOS).

3.2 APPLICABLE DOCUMENTS

The following documents of the exact issue specified form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced and other detail contents of this specification, the detail requirements herein are considered superseding.

3.2.1 Specifications

Military

MIL-P-116E	Preservation, Method of

TRW

EV2	Environmental Specification Qualification, Qualification/ Acceptance and Acceptance Test Requirements for EOS Components
EV2	EOS Electromagnetic Interference Requirements Specification
2A014	Connector, Rectangular, Multi-Pin, MIL-C-24308 Type

3.2.2 Standards

Military

MIL-STD-129E	Marking for Shipping and Storage
MIL-STD-130D	Identification Marking of U.S. Military Property

MIL-STD-143B	Military Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-794C Appendix D	Parts and Equipment, Procedure for Packaging and Packing of
MIL-STD-889	Dissimilar Metals
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment Facilities

NASA

NHB5300.4(3A)	Requirements for Soldering Electrical Connections

3.2.3 Drawings

TRW

C-TBD	High Resolution Pointable Imager, EOS, Outline and Mounting Drawing

3.2.4 Other Documents

TRW

PAR-700-	Mission Assurance Requirements for Subcontractors - EOS

3.3 REQUIREMENTS

The unit described by all the requirements of this section will pass all of the examination, analyses, and tests specified in Section 3.4.

3.3.1 General Description

The HRPI scans the ground below the spacecraft collecting radiation in each of four spectral bands. The magnitude of developed analog signals depend upon the radiation intensity in each band. These signals, along with appropriate synchronization and housekeeping signals, are processed by a government-furnished multiplexer and an A/D electronics unit.

3.3.1.1 Spacecraft Orbit Details

The satellite is three-axis stabilized in an orbit that is sun synchronous and circular, with an orbit inclination of 99 degrees. The design altitude is 717 kilometers and the north to south equatorial crossing time is 11:00 a.m. local time.

3.3.2 Characteristics

The following subparagraphs define the performance and the physical characteristics as well as the requirements for reliability, maintainability, safety, environment, transportability, and storage.

3.3.2.1 Performance

The instrument will have the following performance characteristics.

3.3.2.1.1 Spatial Coverage

The instantaneous field of view (IFOV) of each detector is swept in a direction cross-track to the ground path of satellite. Contiguous coverage in the track direction is generated by appropriately timing successive cross-track scans as the satellite advances in its ground track path. The scanning system for the HRPI may be either mechanical or electronic. If mechanical, scanning may be performed in the image plane, object plane, or a combination of both.

3.3.2.1.1.1 Alignment Reference

An alignment cube will be mounted to the front face of the HPRI (Figure 3-1). All mirror surfaces on the cube will be orthoginal to within 1.0 arc-seconds. Normals to these surfaces define the instruments X_r, Y_r, and Z_r axes. The X_r axis will nominally be aligned on the spacecraft with the velocity vector. The Z_r axis will nominally be aligned on the spacecraft with the Nadir vector.

3.3.2.1.1.2 Scanned Field of View

The scanned field of view is the solid angle resulting from motion of the IFOV by the scanning mechanism. The width of this scanned field will at least be 3.84 degrees as measured in the Y_r-Z_r plane. The field of view of the central detector of the band 1 array will be the reference IFOV for mechanical scanning. For electronic scanning that IFOV will be the detector of band 1 located on the Y field of view edge.

3.3.2.1.1.3 Scan Line Synchronization

A scan line synchronization reference signal will be provided with each line of video in each spectral band, and will also be provided on a separate output line with TTL output characteristics. For mechanical scanning, the low-to-high transition in this sync signal occurs when the center of the IFOV, for the central detector of the band 1 array, is nominally 1.92 degrees, from the X_r-Z_r plane as measured in the Y_r-Z_r plane. The sync signal occurs when the reference IFOV is sampled. The short-term stability (< 10 seconds) of this sync position will be $\pm 1.4\ \mu$ radians 1σ. The long-term stability (10 seconds) will be $\pm 14\ \mu$ radians 1σ. The timing between successive scan syncs will be consistent with the requirement to assure that the final reconstructed image is maintained in line-to-line alignment to better than 1.0 meters (0.1 IFOV).

3.3.2.1.1.4 Scan Linearity and Stability

For mechanical scanning define scan vector (O_s) as the vector at the center of the reference IFOV, for electronic scanning define O_s to be the center of the instantaneous sampled field-of-view. Define scan time (t_r) as the time measured from the transition of the scan line sync signal. For the same scan time, the orientation of scan vector O_s, relative to the X_r, Y_r, Z_r frame, will be repeatable to $\pm 1.4\ \mu$ radians (1σ) and $\pm 14\ \mu$ radians (1σ) respectively for short (< 10 seconds) and long (> 10 seconds) observation periods. If the long-term stability can not be met, then other instrument signals, such as an encoder output should be provided. Their quality must allow ground correction of the data, consistant with the requirement to provide better than 1.0 meter registration of the IFOV's within the scanned field. The angular rates of vector O_s will be constant within ± 1 percent (1σ) over the total scanned field of view. The rates should be alterable by ground command to accommodate an altitude range of 717 ± 10 kilometers.

3.3.2.1.1.5 Band-to-Band Registration

Points imaged simultaneously in separate bands will be registered to each other within ± 10 percent of an IFOV in the along and cross-track directions. Constant time delays between the data from one band and another band may be accommodated.

3.3.2.1.1.6 Pointability

The scanned field-of-view will have ±30 degrees offset (off-nadir) pointing capability. The pointing position will be commandable in 0.5 degrees increments. Pointing position shall be repeatable to within 0.1 degrees and measureable to within 0.05 degrees. Momentum compensation techniques will be employed while changing the field of view position to keep the HRPI within mechanical interface requirements.

3.3.2.1.2 Spatial Resolution

Using HRPI information, it is desired to ultimately generate maps at a nominal resolution of 10 meters for each of four color bands. In order to ensure this resolution, the following performance constraints are imposed.

3.3.2.1.2.1 Modulation Transfer Function

The spatial resolution of bands 1 through 4 will be adequate to provide peak-to-peak modulation transfer of at least 0.5 for simulated subsatellite target sizes corresponding to 14 μ radian per half cycle of spatial frequency.

3.3.2.1.2.2 Suppression of Stray Radiation

Suitable optical baffles will be used in the telescope to reduce the effect of stray radiation on the performance of the radiometer. The measurement of a minimum brightness target element in any channel will be changed by less than 2 percent of full scale by the presence of a maximum albedo scene extending from 3 to 30 or more elemental fields of view in all directions.

Sun shields may be used on the radiometer if the contractor requires them to supplement the internal optical baffles in suppressing unwanted radation. If sun shields are used they will be limited to the same envelope constraints as the radiometer. The sun shields are to be mounted as part of the radiometer.

3.3.2.1.3 Spectral Coverage

The relative spectral response of the four spectral bands are indicated in Table 3-1. This response characteristic applies to the total instrument, including optics, filters, detectors, etc.

Table 3-1. Spectral Band Characteristics

Band Number	1	2	3	4
Cut-on wavelength (μM)	0.5±0.01	0.6±0.01	0.7±0.01	0.8±0.1
Cut-off wavelength (μM)	0.6±0.01	0.7±0.01	0.8±9.01	1.1±0.01
Edge slopes[(1)] (μM)	0.02	0.02	0.03	0.03
Spectral flatness[(2)]	75	75	75	75
Spurious transmittance[(3)] (%)	5	5	5	5

(1) Edge slope is defined as the wavelength interval between 5 percent absolute transmittance and 70 percent of peak transmittance. The above are maximum values.

(2) Spectral flatness is defined as the percent of the wavelength range (bandwidth) over which the transmittance does not vary by more than 20 percent of the peak transmittance.

(3) Spurious transmittance is the ratio of the integrated solar energy transmitted outside the bandpass to that within the bandpass.

3.3.2.1.4 Sensitivity

Bands 1 through 4 will produce a minimum low spatial frequency signal-to-noise ratio (SNR), defined as peak-to-peak voltage to RMS noise voltage, in accordance with the following table:

Band	Spectral Band (Micrometers)	Minimum Input Radiance (watts/m^2-Ster)	Minimum SNR
1	0.5 to 0.6	2.2	6
2	0.6 to 0.7	1.9	6
3	0.7 to 0.8	1.6	6
4	0.8 to 1.1	3.0	6

The optical design insures that polarization-dependent sensitivity of the instrument does not exceed 0.05. The polarization is defined as the ratio of the difference between maximum and minimum output to the sum of the maximum and minimum output obtained when the plane of the incoming polarized radiation is rotated through 180 degrees.

3.3.2.1.5 Dynamic Range

Each detector channel will include a variable gain linear amplifier in order to better accommodate different scene lighting conditions, and to provide a means of in-flight trimming of gains of one channel relative to the others.

3.3.2.1.5.1 Input Radiance Range at Minimum Gain

The HRPI will be capable of providing calibrated radiance measurements of scenes having radiance values from noise level to those input levels indicated in the following table.

Band	Spectral Band (Micrometers)	Maximum Input Radiance (watts/m^2-Ster)
1	0.5 to 0.6	36.3
2	0.6 to 0.7	29.7
3	0.7 to 0.8	23.1
4	0.8 to 1.1	36.3

3.3.2.1.5.2 Gain Range

The linear gain in each individual detector channel will be selectable, by ground command, to one of eight discrete levels.

Gain State	Relative Gain	Gain State	Relative Gain
0	1.0	4	1.46
1	1.1	5	1.61
2	1.21	6	1.77
3	1.33	7	1.95

3.3.2.1.6 Radiometric Accuracy

In order to maintain radiometric measurement accuracy for the total mission duration, both internal and reference sources will be used to periodically calibrate the system at discrete input radiance levels. Calibration at intermediate levels is interred by using an internal milti-level voltage generator to determine the nonlinear characteristics of the electronics. These calibration references will either be rendered as calibration data for gound computer correction or used internal to the instrument to maintain constant overall gain.

3.3.2.1.6.1 Accuracy

The end-to-end transfer function (output signal versus input radiance) for each detector channel will be known to an absolute radiometric accuracy of ±10 percent, of full scale radiance. The relative gain of one detector channel with respect to another will be known to within ±1 percent, of full scale radiance.

3.3.2.1.6.2 Internal Radiometric Calibration

Separate video signal outputs will be generated for each detector channel. Each video signal, during a line scan, will include the radiometric signal while scanning the earth scene, and also while viewing internal calibration targets. In the case of an electrically sampled photo diode array sensor (non-mechanical field of view scanning), the following applies:

- Calibration will not be required during each line scan
- Calibration will be performed upon command
- Calibration will be performed before and/or after each picture-taking mission.

For bands 1 through 4, one high level, one low level, and one dark reference light source will be scanned. The high and low level radiance levels will be near the extremes of the dynamic radiance range defined in paragrapn 3.2.1.5.1. Any light source parameters, such as current or temperature, necessary to define the source brightness to an accuracy consistent with the end-to-end accuracy specified in paragraph 3.2.1.6.1 will be included in the housekeeping data.

3.3.2.1.6.3 Voltage Calibration Signal

The voltage calibration signal will consist of a ramp calibration.

- The ramp calibration signal will consist of the output of a D/A generator which increases one step per scan.
- A ramp will be generated every 1024 scans of the radiometer. The ramp voltage shall vary from 0 to full scale volts and will have a precision of 10 bits.
- The ramp calibration signal will be added to the video signal train during the temperature calibration region of the scan.

3.3.2.2 Physical

3.3.2.2.1 Weight

The maximum weight of the entire HRPI subsystem (optics, electronics, cooler, insulation, etc.) will not exceed 182 kg (400 lbs), not including 6 kg for a G. F. E. Id signal processor.

3.3.2.2.2 Size, Shape, Center of Gravity, and Mounting

The mounting of the HRPI will be via three points located at the sides normal to the long axis. (Figure 3-1.) Two opposing mounts define an axis through the center of gravity. The third mounts restrains rotation about this axis. The maximum envelope size will not exceed 183 x 97 x 102 cm (cross-track axis x nadir x track axis). Optics, momentum compensation, electronics, and insulation are to be confined to this volume. Calibration targets may be mounted outside this volume but must be confined within the projection towards nadir of the maximum length and width dimensions given above. Center of gravity will be as close as possible to the middle of the instrument and its mounting points to avoid long cantilevered arams. The HRPI will accommodate the given volume the following modules:

Module	Size	Weight (lb)	Power (watt)
MODS	5.5 x 6 x 8	9	13
DIV	1 x 6 x 8	1.2	2.8

3.3.2.3 Interface Requirements

3.3.2.3.1 Electrical Interface

The anticipated electrical input signal and output signal parameters, the power requirements, and the electrical performance characteristics of the radiometer are given in this section. All specified characteristics will be within tolerance over the lifetime of the equipment despite the combined effects of signal impedance, and power supply variations (within specified tolerances, but taken at worst-case values), radiation degradation, and environmental extremes.

3.3.2.3.1.1 Input Signals

The presence of any, all, or none, of the input signals applied in any sequence will not damage the equipment, reduce its life expectancy, or cause any malfunction either when the radiometer is powered or when it is not.

8.0 MHz Timing Signal Input. The characteristics of the 8.0 MHz timing signal are as follows:

- Signal type: constant frequency symmetrical trapezoidal wave.
- Frequency: 8.0 MHz
- Frequency stability: ±0.003 percent over a short-term period of 24 hours.
- The signal to noise ratio of the timing signal will be 20 dB peak-to-peak signal to RMS noise or greater. The noise peaks will not exceed one fourth of the clock signal amplitude.
- Signal levels will be TTL compatible.

High level: $5.0^{+0.5}_{-2.6}$ volts

Low Level: $0.0^{+0.25}_{-0.0}$ volts

All digital signals used in the HRPI will be derived from this clock signal.

Command Signals. Two 16-bit command words are available that will be updated every 120 seconds. One word will contain all of the on/off commands for separate portions of the instrument (heater, momentum compensation, etc.). The other word contains magnitude information (pointing position, gain select, etc.). One data clock (1 MHz) signal, two data enable lines, and two data lines comprise the command interface. The enable line(s) is high for 16-data clock periods during data transfer. All signals will be TTL compatible.

Power Subsystem. The power to the thematic mapper will be unregulated +28 VDC (negative side grounded). Power ground bus to signal ground bus isolation, except at the common tie point external to the instrument, will be provided in the TM by the use of DC-DC converters or DC-AC inverters with the required input/output load characteristics. The basic power bus characteristics are given below:

Bus voltage	+28 ±7 volts
Source impedance	0.25 ohms (0 to 5 kHz)
Ripple and noise	500 mv p-p (5 Hz to 100 kHz)
Transients due to:	
Load changes	±1 volt for 100 ms
Failure modes	Bus may drop to μ20 v or rise to +38 v for 100 ms

The power consumption of the instrument will not exceed 100 watts. Heater power will not exceed 50 watts.

Telemetry Power. A separate +28-volt line will be provided for housekeeping telemetry circuits.

3.3.2.3.1.2 Output Signals

General. The data from each band of the HRPI will be interfaced with the digital signal processor (not part of this contract) in analog fashion. In addition to these analog signals, the line synchronization will also be routed to the signal processor on a separate buffer isolated line. Short circuit protection of all outputs will be provided. The instrument will operate within specification, except for the shorted output while the output is shorted, and the entire radiometer will operate within specification after removal of a temporary short.

The digital signal processor/HRPI interfaces will be designed to take place within the HRPI.

Radiometer Signal Output

- Positive type analog signal (mechanical scanners will restore DC level for bands 1 through 4 each scan line when the radiomete views an appropriate black target).
- The signal amplitude will be from 0 to 2.0 volts. At gain state 0, (paragraph 3.2.1.5.2) the gain will be set so that +1.9± 0.05 volt corresponds to the maximum radiance input (paragraph 3.2.1.5.1). The gain setting allows for an adjustable maximum radiance input by changing a fixed resistor in an amplifier with a maximum of disassembly of the instrument.

The signals from the radiometer when viewing the high-level calibration source will be measured when the radiometer is maintained at its nominal temperature. The radiometer will be designed so that the signal obtained when viewing the same source does not vary more than 60 mV when the instrument temperature is varied over the entire temperature range.

- The low frequency cutoff will be such that the signal droop is less than 0.39 percent of the full signal amplitude during the time of one scan line.
- The drift from scan line to scan line will not exceed 0.5 percent of the full scale amplitude.
- Scanning a step function input in radiance will produce a maximum overshoot of 2 percent of the final amplitude with less than one cycle of the ringing frequency and maximum duration of one microsecond.
- The output impedance will be 100 ohms or less; output capacitance will be less than 20 pf. The output will be capable of driving capacitances of up to 100 pf in the signal processor.

Sync Pulse Signal Output. The scan line to scan line jitter, including noise, of the synchronization pulse will be equivalent to less than 0.1 of an IFOV. The jitter of the synchronization pulse between any two scan lines within a 20-minute period will be within one IFOV. The output will be TTL compatible.

Electronic Reticles. The HRPI will provide to the signal processor electronic reticle signals. Each signal will be within the range 0 to 2.0 volts. The output impedance will be 100 ohms or less; output capacitance will be less than 20 pf. The output will be capable of driving capacitances of up to 100 pf in the signal processor.

Telemetry Outputs. Enough telemetry points will be designed for evaluation of the status and performance and to troubleshoot the radiometer in the event of difficulties. It will be possible to obtain telemetry regarding all radiometer temperatures whether the radiometer electronics are on or off. It will be possible to short any telemetry output to the power bus, or to ground, or to other telemetry outputs without damaging the telemetry circuitry or affecting in any manner whatsoever the performance of the instrument.

- Four 8-bit digital telemetry words are available for transmittal of command verification and digital housekeeping data. One data clock (1 MHz) signal, four data enable lines, and four data lines comprise the digital telemetry interface. The enable line(s) is high for eight data clock periods during data transfer. All signal will be TTL compatible.

- As many as 50 analog signals, relating instrument internal temperatures, voltages, and currents can be accommodated by the telemetry subsystem. Signals will be sampled every 2 seconc with 8-bit resolution. (Except the mirror pointing measurement signal will have 11-bit resolution.) The voltage range will be 0 to 2.0 volts. Output impedance will be less than 100 ohms.

Test Points. Test points will be provided for the HRPI to the extent necessary to determine the status of the instrument as well as metering points by which alignment of the instrument may be implemented.

The test points may be used during testing. Short circuit protection of these points will be provided. The HPRI will operate within specifications in the event any test point is shorted to power bus, ground, or another test point, and upon removal of the short. All test points will be provided through a separate keyed connector(s).

As a minimum, the location of test points will be as follows:

- Band 1 video signals
- Band 2 video signals
- Band 3 video signals
- Band 4 video signals
- Temperature calibration signals
- Sync pulse signal after phasing with 1.0 MHz clock
- Midscan pulse
- Externally introduced signal to cause DC restoration
- Voltage calibration signal.

3.3.2.3.2 Thermal Interface

The radiometer will be designed to operate over a temperature range of 20 ±10°C. The instrument will be thermally isolated from the spacecraft. Therefore, the instrument will contain an active thermal control system, and remove the heat from the HRPI electronics, including the G. F. E. 'd signal processor by radiative means. No more than 1 watt of heat may be transferred to the structure at the HRPI mounting points. The temperature of the spacecraft structure will range between $10^{o}C$ and $30^{o}C$. Continuous instrument operation during the total orbit should be assumed in the thermal design.

3.3.2.3.3 Mechanical Interface

The mechanical interface will be as defined in TRW drawing TBS.

3.3.2.3.3.1 Allowable Experiment Disturbance Levels

Periodic momentum with frequencies exceeding 0.1 Hz (cutoff of control system) will not produce a resultant rigid spacecraft motion having a peak value greater than 5 μ radians for a spacecraft having a moment of inertia of 1000 slug-ft^2.

Momentum variations with frequencies within the control system passband ($0 \leq f < 0.1$ Hz) will not exceed a total momentum level of 0.2 ft-lb-sec.

3.3.2.4 Reliability

The reliability requirements are defined in paragraph 5.3.5.

3.3.2.4.1 Reliability Prediction

The instrument will have a probability of successfully surviving launch, boost, injection and 2 years in orbit of at least 0.900 under operating and nonoperating usage and environmental conditions as specified herein.

3.3.2.4.2 Redundancy

There is no specified redundancy requirement except for requirements deemed necessary by the manufacturer to ensure meeting the survivability requirement (paragraph 3.2.4.1).

3.3.2.4.3 Failure Reporting

A failure is defined as any out of specification condition. These conditions will be reported as specified in paragraph 5.3.7.

3.3.2.5 Maintainability

The instrument will be designed to give consideration to accessibility and interchangeability.

3.3.2.5.1 Service and Access

The instrument will be designed to permit its removal and replacement with a minimum of disturbance to associated or adjacent equipment.

3.3.2.6 Safety

Safety will be designed into the equipment to the maximum degree possible, consistent with the performance requirement of this specification and the safety requirements as defined in paragraph 5.3.8.

3.3.2.6.1 Fail Safe

A single part failure will not adversely affect any other spacecraft system or unit.

3.3.2.7 Environment

The unit will be designed to withstand the environmental conditions encountered during assembly, test shipping, handling and storage, prelaunch, launch/ascent and orbital operations in accordance with the environmental conditions specified in EV2-TBD, with the exception of meteoroids and earth thermal radiation. Appropriate packaging and/or protection devices external to the unit should be used for protection during shipping, handling, storage, and prelaunch operations.

3.3.2.8 Design Life

The instrument will be capable of performing as specified for not less than 2 years under all natural combinations of the operating environmental conditions including wear, environmental degradations, and expendables. This period is in addition to the storage requirements of paragraph 3.3.2.10.

3.3.2.9 Transportability/Transportation

The instrument will be designed to be transported by common carrier with a minimum of protection. Special packaging will be used as necessary to assure that transportation methods do not impose design penalties.

3.3.2.10 Storage

The instrument will be capable of being stored for a minimum of 3 years without requiring repair, maintenance, or retesting at the end of storage.

3.3.3 Design and Construction Standards

The design and construction of the instrument will be in accordance with the following requirements.

3.3.3.1 Parts, Materials and Processes

The selection of parts, materials, and processes will be in accordance with paragraph 5.3.6. The reliability level of electronic parts used for the construction of the instrument will be as specified in paragraph 5.3.6. All parts, materials, and processes used by TRW subcontractors must have TRW approval prior to use.

3.3.3.2 Selection of Specifications and Standards

Selection of specifications and standards for necessary commodities and services not specified herein will be in accordance with the provisions of MIL-STD-143.

3.3.3.3 Drawings

Drawings will be prepared in accordance with paragraph 5.3.4.

3.3.3.4 General

3.3.3.4.1 Thermal Design

The instrument will be designed so that all internal sources of heat have adequate heat flow paths to the radiative coolers. All environmental requirements of this specification and of EV2-TBD will be considered in the thermal design. The instrument will withstand the specified temperature extremes without performance degradation.

3.3.3.4.2 Finish

Protective coatings will be applied to the unit for corrosion protection and for thermal control. The coating will withstand the environmental conditions of EV2-TBD without any damage that would affect operational performance and will meet the electrical bonding requirements of EV2-TBD.

3.3.3.4.3 Magnetic Requirements

The unit will be capable of operating in a DC magnetic field as specified in EV2-TBD.

3.3.3.5 Electrical

The unit will meet the requirements as specified in EV2-TBD. The cable run for the instrument will be at least 3 feet and not exceed 4 feet. The electrical interface and connector type will be as described in TRW drawing TBD.

High Voltage (HV).

- Design philosophy will be in accordance with the requirement that any HV system will not be damaged and operate normal through critical altitude.
- Any component not encapsulated having an applied voltage of 100 volts must be well vented.
- No hollow core components may be used in any HV section.
- The total scanner package including all compartments must have a leak down time constant in a vacuum of a few seconds.
- Wax treated components will not be used.
- Shielding of any HV power supply will be provided if RF fields produced by HV supply can damage adjacent components.
- HV power supplies will be located in the proximity of loads.
- HV cabling will be shielded.
- No demonstration of corona survival is planned.

3.3.3.6 Mechanical

3.3.3.6.1 Lubrication

The mechanisms which require lubrication will be given special consideration in their design, testing, processing, and handling. Rotating and translating mechanisms will be driven with torque/force margins 6 dB over the maximum torque/force expected. This will assure continued operation of the system as degradation or loss of lubrication occurs.

The lubricant's rate of evaporation must be considered both from the standpoint of loss of lubrication and contamination of optical components. The scanner system design will reflect the sensitivity of the lubrication problem and verification testing performed at a component level where a critical situation exists.

3.3.3.7 Nuclear

3.3.3.7.1 Radioactivity Control

The unit will be designed to minimize all possible radioactive sources. Isotopes of radium, thorium, uranium, and their radioactive daughter products are to be avoided. Examples of components which contain these materials are:

- Magnesium – thorium alloys used in structural material
- Luminous paint
- Depleted uranium weights and counterbalances
- Radioactive fuel gauges.

In addition, neutron radiography will not be used on flight hardware.

Any radioactive source used in the unit must have prior approval from TRW.

3.3.3.8 Fungus Resistance

Materials that are nutrients for fungus will not be used when their use can be avoided. Where used and not hermetically sealed, they will be treated with a suitable fungicidal agent that meets the outgassing requirements of paragraph 5.3.6.

3.3.3.9 Dissimilar Metals

Unless suitably protected against electrolytic corrosion, dissimilar metals will not be used in contact with each other. Dissimilar metals will be as defined in MIL-STD-889.

3.3.3.10 Contamination/Cleanliness Control

Contamination/cleanliness requirements of the assembled unit will be in accordance with paragraph 5.3.6.

3.3.3.11 Coordinate Systems

The instrument reference coordinate system is identified in Figure 3-1.

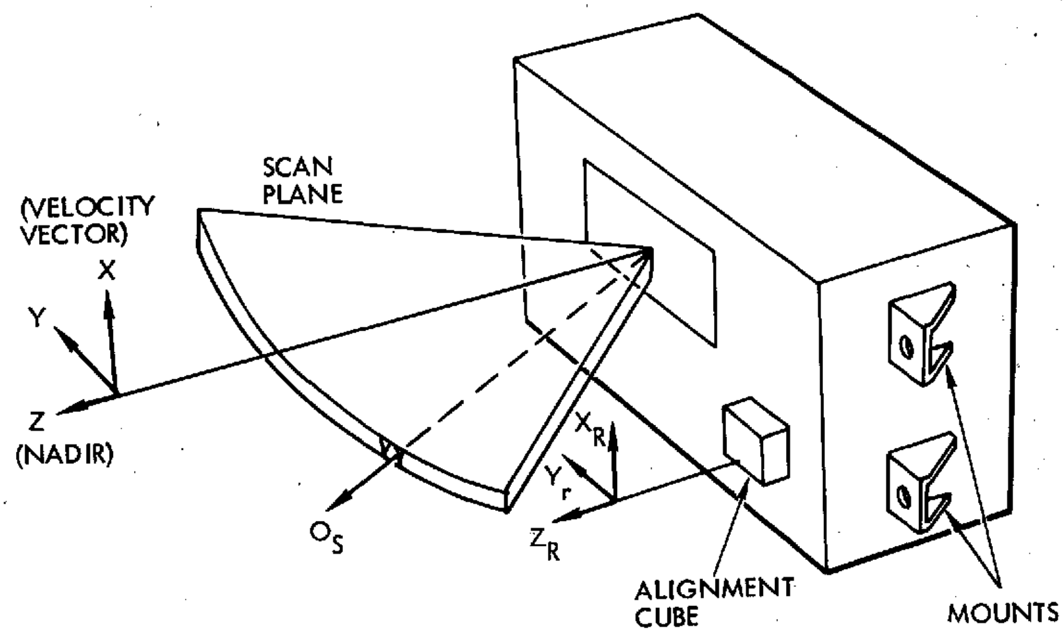

Figure 3-1. HRPI Coordinate Frame

3.3.3.12 Interchangeability and Replaceability

Each unit will be directly interchangeable in form, fit and function with other units of the same part number. The performance characteristics and dimensions of each unit will be uniform to permit equipment interchange with a minimum of adjustment and recalibration.

3.3.3.13 Identification and Marking

The unit will be identified in accordance with the provisions of MIL-STD-130. Marking will include but not be limited to the following:

- Part number
- Serial number

- Item name
- Project name (EOS)
- Actual weight to be determined to an accuracy of ±0.01 pound. Weight to be specified in pounds.
- Contract number
- Manufacturer's name
- Date of manufacture.

3.3.3.14 Workmanship

Workmanship quality will be such that the reliability inherent in design is not degraded. Workmanship acceptability of manufacturing processes will be assured to requirements depicted in applicable drawings, specifications and standards, and as further delineated by quality operating instructions, process specifications, and workmanship standards.

3.3.3.14.1 Soldering Requirements

Soldering of electrical connections will be performed in accordance with NHB5300.4(3A).

3.3.3.15 Human Performance/Human Engineering

MIL-STD-1472 will be used as general guidance for man/machine interfaces.

3.3.4 Other Requirements

3.3.4.1 Optical Materials Radiation Resistance

Care will be exercised in the selection of optical materials to insure against degradation of unit performance beyond specified tolerances as a result of the prolonged exposure (714 km orbital altitude, 99 orbital inclination) to ultraviolet radiation and trapped proton and electron fluxes as specified in Table 2 of EV2-TBD.

3.4 VERIFICATION

3.4.1 Responsibility for Inspection and Test

The supplier is responsible for compliance to all test requirements as specified herein.

3.4.1.1 Quality Assurance Provisions

The unit will be fabricated and inspected in accordance with the quality assurance requirements as defined in paragraph 5.3.7.

3.4.2 Verification Methods

Verification methods shall include similarity, analysis, inspection, and test.

3.4.3 Development

The extent of development verification/testing will be recommended by the supplier except as specifically required by the Statement of Work. Development verification is the basis of verifying the feasibility of the design approach and providing confidence in the ability of the unit to pass qualification/acceptance verification. All development test data will be available for TRW review.

3.4.4 Classification of Verification

The verification of the unit will be classified as follows:

- Qualification/Acceptance (See Section 3.4.5)
- Acceptance Verification (See Section 3.4.6)

3.4.5 Qualification/Acceptance Verification

The following subparagraphs specify the requirements for and the methods used to verify that the design and performance requirements of Section 2.3 will be satisfied.

3.4.5.1 Similarity

Not applicable.

3.4.5.2 Inspection

The following requirements of Section 3.3 will be verified by an inspection of the equipment and/or review of design and fabrication data.

Paragraph	Requirement
3.3.2.2.1	Weight
3.3.2.2.2	Size, Shape, Center of Gravity and Mass
3.3.2.3.1	Electrical Interface

3.3.2.3.3	Mechanical Interface
3.3.2.5	Maintainability
3.3.2.6	Safety
3.3.2.6.1	Fail Safe
3.3.2.9	Transportability/Transportation
3.3.3.1	Parts, Materials and Processes
3.3.3.2	Selection of Specifications and Standards
3.3.3.3	Drawings
3.3.3.4.2	Finish
3.3.3.5	Electrical
3.3.3.7.1	Radioactivity Control
3.3.3.8	Fungus Resistance
3.3.3.9	Dissimilar Metals
3.3.3.10	Contamination/Cleanliness Control
3.3.3.13	Identification and Marking
3.3.3.14	Workmanship
Paragraph	Requirement
3.3.3.14.1	Soldering Requirements
3.3.3.15	Human Performance/Human Engineering

3.4.5.3 Analyses

The following requirements of Section 3.3 will be verified by analytical data.

Paragraph	Requirement
3.3.2.1.1	Spatial Coverage
3.3.2.1.1.1	Alignment Reference
3.3.2.1.1.2	Scanned Field of View
3.3.2.1.1.3	Scan Line Synchronization
3.3.2.1.1.4	Scan Linearity and Stability
3.3.2.1.1.5	Band to Band Registration
3.3.2.1.1.6	Pointability
3.3.2.1.2	Spatial Resolution

3.3.2.1.2.1	Modulation Transfer Function
3.3.2.1.2.2	Suppressing of Stray Radiation
3.3.2.1.3	Spectral Coverage
3.3.2.1.4	Sensitivity
3.3.2.1.5	Dynamic Range
3.3.2.1.6	Radiometric Accuracy
3.3.2.3.1.2	Output Signals
3.3.2.3.2	Thermal Interface
3.3.2.3.3.1	Allowable Experiment Disturbance Levels
3.3.2.4	Reliability
3.3.2.8	Design Life
3.3.3.4.1	Thermal Design
3.3.3.4.3	Magnetic Requirements
3.3.3.6.1	Lubrication
3.3.11	Coordinate System
3.3.12	Interchangeability and Replaceability
3.3.4.1	Optical Materials Radiation Resistance

3.4.5.4 Demonstrations

Not Applicable.

3.4.5.5 Tests

The following requirements of Section 3.3 will be verified by qualification/acceptance testing.

Paragraph	Requirement
3.3.2.1.1	Spatial Coverage
3.3.2.1.1.1	Alignment Reference
3.3.2.1.1.2	Scanned Field of View
3.3.2.1.1.3	Scan Line Synchronization
3.3.2.1.1.4	Scan Linearity and Stability
3.3.2.1.1.5	Band to Band Registration
3.3.2.1.1.6	Pointability
3.3.2.1.2	Spatial Resolution
3.3.2.1.2.1	Modulation Transfer Function
3.3.2.1.2.2	Suppression of Stray Radiation

3.3.2.1.3	Spectral Coverage
3.3.2.1.4	Sensitivity
3.3.2.1.5	Dynamic Range
3.3.2.1.6	Radiometric Accuracy
3.3.2.3.1.2	Output Signals
3.3.2.7	Environment

3.4.5.6 Test Sample

One unit which has passed all acceptance inspections and tests will be used for qualification.

3.4.5.7 Qualification/Acceptance Sequence

Qualification/acceptance inspection and test consists of these examinations and tests in the following sequence:

- Pre-environmental inspection of product
- Pre-environmental functionals
- Random vibration
- Abbreivated functionals
- Shock
- Abbreivated functionals
- Thermal vacuum
- Post-environmental functionals
- Post-environmental inspection of product

3.4.5.8 Environmental Testing

Qualification/acceptance environmental tests listed in paragraph 3.4.5.7 will be performed as specified in EV2-TBD.

3.4.5.9 Electromagnetic Compatibility Testing

EMC testing will be performed in accordance with EV2-TBD.

3.4.5.10 Test Report

Following completion of qualification/acceptance tests, a test report will be prepared evaluating results of the tests.

3.4.5.11 Qualification/Acceptance Test Methods

3.4.5.11.1 Pre-Environmental Inspection

Prior to qualification/acceptance tests, the unit will be examined for compliance to the inspection requirements of paragraph 3.4.5.2.

3.4.5.11.2 Pre-Environmental Functional Tests

Verification that the equipment performs as specified herein will be achieved by the completion of the functional tests which include, as a minimum, testing of the requirements specified in paragraph 3.4.5.5.

3.4.5.11.3 Vibration

The random vibration exposures will be performed as specified in EV2-TBD. During the exposures, mating connections will be installed on all electrical connectors. The unit will be non-operating during exposures.

3.4.5.11.4 Abbreivated Functional Tests

After completion of vibration and shock exposures, tests will be performed to verify the following performance requirements:

Paragraph	Requirement
3.3.2.1.1.1	Alignment Reference
3.3.2.1.1.2	Scanned Field of View
3.3.2.1.1.6	Pointability
3.3.2.1.4	Sensitivity

3.4.5.11.5 Shock

During exposures, mating connectors will be installed and the unit will be non-operating.

3.4.5.11.6 Qualification Thermal Vacuum

Tests to verify the following functional requirements will be performed near the end of the soak period at both the high operational temperature and the low operational temperature during each cycle.

Paragraph	Requirement
3.3.2.1.1.1	Alignment Reference
3.3.2.1.1.2	Scanned Field of View
3.3.2.1.1.6	Pointability
3.3.2.1.4	Sensitivity

3.4.5.11.7 Post-Environmental Functional Tests

After all environmental exposures have been completed, tests will be performed to verify all the performance requirements listed in paragraph 3.4.5.5.

3.4.5.11.8 Post-Environmental Inspection

The unit will be inspected by visual examination or measurement to verify the following requirements:

Paragraph	Requirement
2.3.2.2.2	Size, Shape Center of Gravity and Mass
2.3.2.3.3	Mechanical Interface
2.3.3.4.2	Finish
2.3.3.14	Workmanship

3.4.5.12 Test Conditions

Unless otherwise specified for specific tests listed under Test Methods, qualification/acceptance inspection and tests will be conducted in accordance with the conditions and tolerances specified herein.

3.4.5.12.1 Standard Test Conditions

All examinations and tests will be conducted under the conditions specified in EV2-TBD, EV2-TBD, and this specification.

3.4.5.12.2 Equipment Accuracy

The accuracy of the measurement equipment will be accomplished by using secondary standards traceable to the National Bureau of Standards.

3.4.5.12.3 Test Tolerances

Except as specifically noted in the Test Methods, the maximum allowable tolerances (excluding measuring equipment errors) for test conditions and measurement will be as specified in EV2-TBD and as follows:

- Voltage or current measurements — DC: ±0.5 percent
- Sensor angle settings: ±30 arc-seconds

3.4.5.12.4 Temperature Changes

Changes from one specified temperature to another will be accomplished as specified in EV2-TBD.

3.4.5.12.5 Equipment Alignment

The alignment tolerances between the test equipment axes and the instrument axes will be as necessary to achieve the test objectives. These tolerances will be determined by the subcontractor subject to TRW approval.

3.4.5.12.6 Radiation Source

The radiation source used during the functional tests described in this document and its calibration must be approved by TRW Systems. This source will have uniformity, repeatability, and measurable radiometric accuracy consistent with the instrument performance requirements specified in Section 3.3.

The compliance of the illumination source to the above requirements must be demonstrated prior to initiation of tests. This may be done by subjecting the source to such tests as are necessary to measure its performance as defined in this specification. These tests may be performed by a qualified independent testing organization or as an alternate, the tests may be performed by the vendor and witnessed by TRW Systems prior to the performance tests.

3.4.5.13 Failure Criteria

The unit will exhibit no failure, malfunction, or out-of-tolerance performance degradation as a result of the examinations and tests specified. Any such failure, malfunction, or out-of-tolerance condition will be cause for rejection.

3.4.5.14 Rejection and Retest

If a failure, malfunction, or out-of-tolerance performance degradation occurs during or after a test, testing will be discontinued, or as otherwise directed by TRW, until the failure, malfunction, or out-of-tolerance condition (including design defects) is corrected. The pertinent test procedure will be repeated, as approved by TRW, until completed successfully. If the corrective action substantially affects the significance of results of previously completed tests, such tests will also be repeated.

3.4.6 Acceptance Verification

The following subparagraphs specify the requirements for and the methods used to verify that the requirements in Section 3.3 will be satisfied.

3.4.6.1 Inspection

The following requirements of Section 3.3 will be verified by an inspection of the equipment and/or review of design and fabrication data.

Paragraph	Requirement
3.3.2.2.1	Weight
3.3.2.2.2	Size, Shape, Center of Gravity, and Mass
3.3.2.3.1	Electrical Interface
3.3.2.3.3	Mechanical Interface
3.3.3.4.2	Finish
3.3.3.5	Electrical
3.3.3.13	Identification and Marking
3.3.3.14	Workmanship
3.3.3.14.1	Soldering Requirements

3.4.6.2 Analyses

The following requirements of Section 3.3 will be verified by review of analytical data.

Paragraph	Requirement
3.3.2.4.3	Failure Reporting

3.4.6.3 Tests

The following requirements of Section 3.3 will be verified by qualification/acceptance testing.

Paragraph	Requirement
3.3.2.1.1	Spatial Coverage
3.3.2.1.1.1	Alignment Reference

2.3.2.1.1.2	Scanned Field of View
2.3.2.1.1.3	Scan Line Synchronization
3.3.2.1.1.4	Scan Linearity and Stability
3.3.2.1.1.5	Band to Band Registration
3.3.2.1.1.6	Pointability
3.3.2.1.2	Spatial Resolution
3.3.2.1.2.1	Modulation Transfer Function
3.3.2.1.2.2	Suppression of Stray Radiation
3.3.2.1.3	Spectral Coverage
3.3.2.1.4	Sensitivity
3.3.2.1.5	Dynamic Range
3.3.2.1.6	Radiometric Accuracy
3.3.2.3.1.2	Output Signals
3.3.2.7	Environment

3.4.6.5 Test Sample

Each production unit will be acceptance tested.

3.4.6.6 Acceptance Sequence

Acceptance inspection and test consists of these examinations and tests in the following sequence:

- Pre-environmental inspection of product
- Pre-environmental functionals
- Random vibration
- Abbreviated functionals
- Thermal cycle
- Post-environmental functionals
- Post-environmental inspection of product

3.4.6.7 Environmental Testing

Acceptance environmental tests listed in paragraph 3.4.6.6 will be performed as specified in EV2-TBD.

3.4.6.8 Electromagnetic Compatibility Testing

EMC testing is not performed during acceptance testing.

3.4.6.9 Test Report

Following completion of the acceptance tests, a test report will be prepared evaluating results of the tests.

3.4.6.10 Acceptance Test Conditions

All test conditions will be in accordance with EV2-TBD and paragraph 3.4.5.12 of this specification.

3.4.6.11 Acceptance Test Methods

3.4.6.11.1 Pre-Environmental Inspection

Prior to acceptance test, the unit will have been examined for compliance to the inspection requirements of paragraph 3.4.6.1.

3.4.6.11.2 Pre-Environmental Functional Tests

Verification that the equipment performs as specified herein will be achieved by the completion of the functional tests which include, as a minimum, testing of the requirements specified in paragraph 3.4.6.3.

3.4.6.11.3 Vibration

The random vibration exposures will be performed as specified in EV2-TBD. During the exposures, mating connectors will be installed on all electrical connectors. The unit will be nonoperating during exposures.

3.4.6.11.4 Abbreviated Functional Tests

After completion of vibration exposures, tests will be performed to verify the following performance requirements:

Paragraph	Title
3.3.2.1.1.1	Alignment Reference
3.3.2.1.1.2	Scanned Field of View
3.3.2.1.1.6	Pointability
3.3.2.1.4	Sensitivity

3.4.6.11.5 Acceptance Thermal Cycle

Tests to verify the following functional requirements will be performed near the end of the soak period at both the high and low operational temperature during each cycle:

Paragraph	Title
3.3.2.1.1.1	Alignment Reference
3.3.2.1.1.2	Scanned Field of View
3.3.2.1.1.6	Pointability
3.3.2.1.4	Sensitivity

3.4.6.11.6 Post-Environmental Functional Tests

After all environmental exposures have been completed, tests will be performed to verify all the performance requirements listed in paragraph 3.4.5.5.

3.4.6.11.7 Post-Environmental Inspection

The unit will be inspected by visual examination or measurement to verify the following requirements:

Paragraph	Title
3.3.2.2.2	Size, Shape, Center of Gravity and Mass
3.3.2.3.3	Mechanical Interface
3.3.3.4.2	Finish
3.3.3.14	Workmanship

3.4.6.12 Failure Criteria

The unit will exhibit no failure, malfunction, or out-of-tolerance performance degradation as a result of the examinations and tests specified. Any such failure, malfunction, or out-of-tolerance performance degradation will be cause for rejection.

3.4.6.13 Rejection and Retest

If a failure, malfunction, or out-of-tolerance performance degradation occurs during or after a test, testing will be discontinued, or as otherwise directed by TRW, until the failure, malfunction, or out-of-tolerance condition (including design defects) is corrected. The pertinent test procedure will be repeated, as approved by TRW, until completed successfully. If the corrective action substantially affects the significance of results of previously completed tests, such tests will also be repeated.

3.5 PREPARATION FOR DELIVERY

3.5.1 Method of Preservation and Packaging

3.5.1.1 General

The unit will be preserved and packaged in accordance with requirements specified herein.

3.5.1.1.1 Contamination/Cleanliness

Contamination/cleanliness requirements of the assembled unit will be to the requirements of paragraph 5.3.6.

3.5.1.1.2 Drying

The unit will be dried by any process of MIL-P-116 that will not be injurious.

3.5.1.1.3 Preservation

Unless otherwise specified, all units will be preserved and packaged in accordance with the applicable procedures of MIL-P-116.

3.5.1.1.4 Attaching Parts

When attaching parts, such as nuts, bolts, washers, etc., accompany a basic unit, they will be preserved, bagged, appropriately identified and attached to or adjacent to the intended fitting.

3.5.1.1.5 Electrical Connectors

Electrical connectors will be capped with protective dust caps. The caps will be a friction fitting type or threaded type which do not require tape or a mechanical device to secure.

3.5.1.1.6 Critical Surfaces

External machine surfaces and mounting surfaces will be protected by using mounting pads. Materials used for mounting pads will not cause commodity deterioration.

3.5.1.1.7 Wrapping

The unit will be wrapped in an anti-static polyethylene film material, minimum thickness being 4 mil. The wrap will be secured using appropriate tape or tie.

3.5.2 Levels of Preservation and Packaging

Unless otherwise specified, Level C applies to this unit.

3.5.2.1 Requirements

The level of preservation and packaging is Level A for all equipment designated as a spare unit, and Level C for all equipment designated for immediate use on the spacecraft, or in support of the spacecraft.

3.5.2.2 Level A

The unit will be preserved and packaged in accordance with the applicable method of MIL-P-116. Appendix D of MIL-STD-794 will be used to select an appropriate preservation method for Level A.

3.5.2.2.1 Special Requirements

Preservation and packaging selected for Level A will be capable of satisfying the following requirements:

Storage time:	3 years
Humidity:	70 percent of less

3.5.2.3 Level C

The unit will be preserved and packaged in a manner which will afford protection against corrosion, contamination, deterioration, and damage during shipment from the supply source to the first receiving activity for immediate use or use in support of the spacecraft.

3.5.3 Levels of Packing

Unless otherwise specified, Level C applies to this unit.

3.5.3.1 Requirements

The levels of packing will be either Level B for spare units or Level C for immediate use units.

3.5.3.2 Level B

The unit, packaged as specified in Sections 3.5.1.1 and 3.5.2.2, will be packed in exterior shipping containers of the domestic type in accordance with the applicable specification in Tables II or III of MIL-STD-794.

3.5.3.2.1 Special Requirements

The packed unit will be capable of withstanding the environments specified in EV2-TBD.

3.5.3.3 Level C

The unit will be packed in a manner that will provide against damage and contamination during shipment from the supply source to the first receiving activity for immediate use. Shipping containers will be in accordance with rail, air, or motor common carrier rules and regulations as published in their applicable classification guides.

3.5.4 Packaging Design Requirements

Correlation with the unit design, environmental and transportability criteria in Section 3.3 will be a prerequisite of package design.

3.5.5 Marking

All unit, intermediate and shipping containers will be marked in accordance with MIL-STD-129. Other special marking as specified in the subcontract will be applied.

3.5.6 Required Documentation

All required data, i.e., test reports, shipping invoices, etc., will be attached to the exterior surface of the shipping container. Attachment shall be in such manner to preclude loss of these data during handling and shipment.

4. KEY INTERFACE SUMMARY

This section summarizes the key interfaces with the EOS system as an aid to the system and spacecraft designers. It is not intended to alter or modify any of the specifications of Sections 2 and 3.

4.1 THEMATIC MAPPER

4.1.1 Performance

Altitude	717 km
Ground Resolution	30 M
Swath Width	185 km
Operating Time	maximum 36% of orbits maximum 20 min/orbit

Spectral Band (μm)	Minimum Radiance ($W/m^2/ster$)	DC S/N at Minimum Radiance
0.5 to 0.6	2.2	10
0.6 to 0.7	1.9	7
0.7 to 0.8	1.6	5
0.8 to 1.1	3.0	5
1.55 to 1.75	0.8	5
2.1 to 2.35	0.3	5
10.4 to 12.6	20.0	$NE\Delta T = 0.5^{\circ}K$

4.1.2 Output Signals

Signal Amplitude 0 to 2.0 volts

No. of Analog Channels	Data Rate (words/sec/channel)	Bits Required per Word	Source
96	115165	8	Bands 1-6 data
4	28790	8	Band 7 data
50	0.5	8	Housekeeping and command verification

4.1.3 Input Signals

Timing Signal	8 MHz ±0.003% over 24 hrs
Command Signals	2 16-bit words updated each 120 seconds

4.1.4 Electric Power

Bus Voltage	28 ± 7 VDC
Instrument Power	≤100 watts
Heater Power	≤50 watts

4.1.5 Thermal Control

Operating Temperature Range	10 to 30°C
Heat Transfer to Spacecraft	≤1 watt

4.1.6 Mechanical

Weight	<188 kg
Size	183 x 97 x 102 cm
Cooler Cone	Detachable for resupply; clearance required for cover
Viewing Aperture	Clearance required for cover
Allowable Spacecraft	f > 0.1 Hz 5 micro-radians
	f < 0.1 Hz momentum <0.2 ft-lb-sec

4.2 HRPI

4.2.1 Performance

Altitude	717 km
Ground Resolution	10 M
Swath Width	48 km
Operating Time	maximum 36 percent of orbits maximum 20 min/orbit

Spectral Band (μm)	Minimum Radiance (W/m^2/ster)	DC S/N at Minimum Radiance
0.5 to 0.6	2.2	6
0.6 to 0.7	1.9	6
0.7 to 0.8	1.6	6
0.8 to 1.1	3.0	6

4.2.2 Output Signals

Signal Amplitude	0 to 2.0 volts

No. of Channels	Data Rate (words/sec/channel)	Bits Required per Word	Source
304	43136	8	Bands 1-4 data
50	0.5	8	Housekeeping and command verification

4.2.3 Input Signals

Timing Signals	8 MHz ±0.003 percent over 24 hours
Command Signals	2 16-bit words updated each 120 seconds

4.2.4 Electric Power

Bus Voltage	28 ± 7 VDC
Instrument Power	≤100 watts
Heater Power	≤50 watts

4.2.5 Thermal Control

Operating Temperature Range	10 to 30°C
Heat Transfer to Spacecraft	≤1 watt

4.2.6 Mechanical

Weight	188 kg
Size	183 x 97 x 102 cm
Viewing Aperture	Clearance required for cover
Allowable Spacecraft Disturbance Levels	f > 0.1 Hz 5 micro-radians f < 0.1 Hz momentum <0.2 ft-lb-sec

5. CONTRACTUAL REQUIREMENTS

5.1 GENERAL REQUIREMENTS

This section describes requirements of a contractual nature which TRW, if selected as systems contractor, would impose upon the instrument subcontractors.

5.1.1 General Provisions

NASA and TRW's general provisions of purchase are similar. Therefore, we have not included TRW's standard "boilerplate" terms and conditions. (Copies are available if needed.) It is necessary, however, that all terms, conditions, and provisions negotiated by NASA with the instrument contractors be compatible with those contained in the prime (systems) contract.

5.1.2 Special Provisions

- If the contract is incrementally funded, the standard "limitation of buyer's obligation" clause must be included
- Appropriate patent data clauses
- Appropriate proprietary interest clause must be included.

5.1.3 Contract Schedule Provisions

In addition to the special and general provisions, the following clauses or the specific requirements stipulated must be included in the contract schedule provisions.

5.1.3.1 Subcontract Administration

TRW's subcontract administrator for this subcontractor is designated on the cover sheet hereof. TRW may, by written notice to the subcontractor, change the subcontract administrator at any time.

No request, notice, authorization, direction, or order received by the subcontractor and issued, either pursuant to an article or clause of this subcontract, to a provision of any document incorporated into this subcontract by reference, or otherwise, will be binding upon either the subcontractor or TRW, or serve as the basis for a change in the subcontract price or any other provision of this subcontract, unless issued or confirmed in writing by TRW's subcontract administrator named herein or by his authorized representative. Designations of authorized representatives will be in writing and signed by the subcontract administrator. A copy of each such designation, and of each modification or cancellation thereof, will be furnished the subcontractor. The subcontractor is to immediately notify, in writing, the subcontract administrator or his authorized representative whenever a change request has been received from a representative of TRW other than the subcontract administrator, or his authorized representative, which would affect the price, terms and conditions, and delivery schedule of this subcontract.

5.1.3.2 Technical Representative

TRW's subcontract administrator may designate a representative to act as technical representative under this subcontract. Such a representative, if appointed, will be designated elsewhere in this subcontract or in a letter from the subcontract administrator to the subcontractor. The technical representative represents the subcontract administrator in the technical phases of the work; however, the representative will not be authorized to change any of the terms and conditions or cost or fee of this subcontract. Such changes, if any, can be made only by the subcontract administrator or by his authorized representative by a properly executed modification to this subcontract.

5.1.3.3 Resident Representatives

TRW reserves the right to assign representatives on an itinerant or resident basis at the subcontractors facilities or those of lower tier subcontractors for the purpose of maintaining surveillance activities, including the right to witness any or all tests performed as part of the requirements of this subcontract. The subcontractor is to provide TRW's representatives with reasonable facilities and equipment, and unescorted free access to all areas essential to the proper conduct of the aforementioned activity throughout all phases of design, development, manufacturing, testing, packaging, and shipping. In addition, the subcontractor agrees to make available to TRW's representatives pertinent planning, status, and forecast information and such other technical and management reporting information as may be necessary for the representatives to carry out their responsibilities.

The subcontractor agrees to insert the substance of this article, including this paragraph, in each lower-tier subcontract hereunder.

5.1.4 Special Requirements

- NASA must establish a firm cost basis for the negotiated price and provide adequate cost/price data supporting that base cost to accommodate/facilitate change evaluations
- The subcontractor reports identified in Table 5-1 should be specifically identified as a requirement for the instrument subcontracts. Particular note should be made of the cost reporting requirements.

5.1.4.1 Resident Representative Responsibilities

Both a subcontract administrator and a senior engineering representative would be in residence during the development phase, as a minimum. The basic purpose being to expedite necessary engineering changes and contractual direction through direct interface with their subcontractor counterparts. To this end, they will have full authority to approve change classifications and Class II changes. In addition, they will be authorized to give temporary approval to proceed prior to Class I change disposition by the configuration control board (CCB). They will have the responsibility of convening the CCB when necessary; of ensuring that TRW quality assurance personnel are on hand when needed at the specified inspection points; of assisting liaison between subcontractor and TRW personnel; and generally preventing unnecessary delays in the program.

In addition, a quality assurance representative will be in residence as required and supporting engineering specialists may be in residence for periods as considered necessary.

5.1.4.2 Type Contract

We recommend that NASA negotiate an incentive fee type contract with the instrument contractors. A combined incentive/award fee type contract would be acceptable if the prime is so structured. The award fee provisions must, of course, be subject to prime contractor control. In either case (incentive/award fee) appropriate incentives on technical, schedule, and cost should facilitate effective management of the subcontractor's performance.

5.2 STATEMENT OF WORK

5.2.1 Purpose

The purpose of this Statement of Work (SOW) is to define the tasks and effort required of the subcontractor who will supply the equipment (Table 5-2) to be used in a space vehicle.

5.2.2 Scope of Work

The subcontractor will furnish all necessary personnel, facilities, material, and services to design, develop, fabricate, test, and deliver the equipment listed in Table 5-2 and documentation in accordance with the requirements of this SOW and the applicable documents referenced herein.

5.2.3 Delivery Items

5.2.3.1 Equipment

- Engineering models are defined as units which closely approximate final production configuration but need not be manufactured or controlled in the same manner as production equipment. Engineering models are intended to demonstrate that the design, performance, and environmental requirements of the applicable equipment specification will be met by the flight articles.

  Engineering models and engineering development models will become government property. Each such item will be delivered to NASA subsequent to the conclusion of the flight program, but will be retained by the subcontractor during the flight program to aid in diagnosing possible problems in the spaceborne instrument. Such items will be delivered as residual property in the "as is" condition which resulted at the completion of said testing. In the event that an engineering model is designated as a deliverable item in Table 5-2 of the SOW, the specific models so designated will be manufactured, tested, and delivered in accordance with the applicable paragraphs of the SOW and equipment specification rather than delivered as residual property.

- Protoflight or qualification units are defined as units built from formal, released drawings, using approved parts, materials, processes and procedures in accordance with the requirements of the applicable equipment specification, and tested in accordance with the TRW-approved qualification test procedure. The protoflight unit meets all equipment specification requirements and if refurbished becomes a flight spare unit when delivered.

- Flight units will conform to the qualified design configuration, including any changes which have been formally approved by TRW. Flight units will be built from formal, released drawings

28	Failure Report	5.6.1	R	1	4	Within 3 days of each failure
29	Failure Analysis and Corrective Action	5.6.2, 5.6.3, 5.6.4	A	1	4	Within 30 days of each failure
30	Operating Time Logs	5.7	R	1	4	Shipped with each hardware item
31	Limited Life Item List	5.7	R	1	4	"Off-the-shelf" hardware with the proposal. New design with the PDA and CDA Data Package submittals
32	Part Approval Request	6.2.1	A	1	4	As required
33	Parts List and Part Screening Data	6.2.8	R	1	4	Preliminary with proposal. Final 90 days ARO and as changes are approved
34	Materials List	6.3.4	R	1	4	Preliminary with proposal. Final 90 days ARO and as changes are approved
35	Engineering Drawings	4.2.3	R	1	4	Concurrent with PDR and CDR submittals and first deliverable unit
36	Engineering Data List	4.4	R	1	4	Concurrent with CDR submittal and each configuration audit data package
37	"As-Built" Parts List	4.4	R	1	4	One copy with each deliverable hardware item and the balance to the subcontract administrator
38	Class I Engineering Changes	4.3	A	1	4	Prior to MRB review
39	Class II Engineering Changes	4.3	R	1	4	As generated
40	Acceptance Data Package	7.3.3	A		2	1 copy with hardware. 1 copy to SCA
41	Supplier Information Request (SIR)	4.3.4	A		1	As required
42	Mishap Notification	8.3.5	R	TWX		Within 24 hours of each mishap
43	Mishap Report	8.3.5	R	1	4	Within 5 days of each mishap

Table 5-2. Deliverable Hardware and Services

Item	Description	Specification Number	Quantity	Delivery Date ARO

(TO BE DETERMINED)

using approved parts, materials, processes, and procedures. All flight units will be successfully tested by the subcontractor in accordance with the TRW-approved acceptance test procedure.

5.2.3.2 Test Equipment

Deliverable test equipment will conform to the requirements of the applicable equipment specification and will be used for the acceptance testing of the flight units, after calibration to the TRW-approved test equipment calibration procedure. After acceptance testing it will be delivered to TRW for use in systems integration and preflight checkout.

5.2.3.3 Documentation

Deliverable documentation is specified in Table 5-1, "Subcontract Data Requirements List." Descriptions of the required documentation are included in the body of this SOW and in referenced documents.

5.2.3.3.1 Document Approval

As specified in Table 5-1, all documents that are to be submitted for TRW Systems approval will be approved, conditionally approved, or disapproved in writing within 2 weeks of receipt of the documents. If no response is received within 2 weeks, approval is granted. Neither approval nor waiver of such approval will relieve the subcontractor of his obligation to meet requirements of the contract. Corrections or revisions to original submittals will be subject to the same approval cycle. It is intended that all TRW comments and/or disapprovals be made at the time of the original submittals.

Comments and/or disapprovals of resubmittals will address themselves only to the lack of proper incorporation by the subcontractor of the original TRW comments and/or disapprovals.

5.2.3.3.2 Document Review

All documents delivered for TRW review will be for information purposes and the subcontractor may proceed with the work without delay. For all such deliverable documents, TRW Systems retains the right to rejection. This right will be exercised within 2 weeks of receipt of the documents.

5.2.4 Delivery Schedule

5.2.4.1 Equipment

Delivery of the required units will be in accordance with Table 5-2 The dates specified represent dates of receipt of equipment at TRW. Final acceptance will be after receipt and functional checkout of equipment at TRW.

5.2.4.2 Test Equipment

Delivery of the deliverable test equipment will be in accordance with Table 5-2.

5.2.4.3 Documentation

Documentation delivery requirements are as defined in Table 5-1.

5.2.5 Applicable Documents

The documents listed below form a part of this SOW to the extent specified. In the event of conflict between the referenced documents and requirements of this SOW, the latter takes precedence.

1) Attachment 1 to Statement of Work — Deliverable Hardware and Services

2) Attachment 2 to Statement of Work — Subcontract Data Requirements List

3) Equipment Specification

4) Mission Assurance Subcontractor Requirements.

5.2.6 Task Descriptions

5.2.6.1 Program Management

The subcontractor will provide a centralized program management to execute the tasks described in this SOW. A program manager will be named who will possess singular authority to plan and direct the successful and timely attainment of the required effort. Such authority will include management of planning, scheduling, cost control, and overall technical direction of the program.

The program manager will maintain close liaison with TRW through the resident TRW representative and the TRW subcontract manager. Adequate and continuous technical, schedule, and cost control surveillance will be maintained throughout the assignment of specific personnel. The subcontractor will provide qualified personnel such that adequate program supervision and follow-up is assured.

5.2.6.1.1 Program Plan

The subcontractor will prepare and submit to TRW Systems, a program plan describing and scheduling in detail all phases of the subcontractor's program. The plan will identify all significant milestones and define all tasks to be performed in response to this SOW including, but not necessarily limited to:

- Management plan and program organization charts
- Task descriptions
- Milestone charts (including all deliverable hardware and software)
- Description of the management reporting systems to be used to control schedule and cost
- A complete bill of material that identifies those major purchases and subcontracts to be statused as part of the monthly progress report
- Identification of long lead-time/critical components showing supplier and lead time required
- Identification of interface definitions required and corresponding need dates
- The following plans shall be submitted as appendices to the program plan:
  - Mission assurance plan (quality, reliability and configuration management
  - Test Plan
  - Manufacturing plan.

Upon TRW approval of the program plan, the subcontractor will implement the plan, and unless otherwise authorized in writing, execute the work according to the approved program plan. In the event of conflict between the program plan and this SOW, the latter will take precedence.

In addition to the specific plans required by Table 5-1, the following preliminary plans are required with the proposal: manufacturing, mission assurance, engineering development, and test plan.

5.2.6.1.2 Monthly Progress Reports

5.2.6.1.2.1 Technical Progress Report

The monthly technical progress report will be submitted in letter form. Each report will cover the period ending with the last working day of the preceding month, and include as a minimum, the following data.

- Significant accomplishments of the reporting period
- Description of progress and status of all program phases
- Comparison of actual progress versus the program plan, both technical and schedule, and including a status report on all long-lead/critical delivery items
- Discussion and analysis of significant problems (failures, malfunctions, etc.)
- Recommendation for action by TRW or the subcontractor for resolution of outstanding problems
- Summary of specific plans for the next reporting period
- A list of program documents generated during the reporting period including their status (submitted, approved, being revised, etc.)
- A report of critical parts substitution
- A summary of failures, malfunctions and test discrepancies starting with failure tabulations for subassemblies (beginning with the engineering models)
- Summary test data and analysis for critical tests.

5.2.6.1.2.2 Financial Management Report

As a part of his program management plan, the seller will identify the management reporting system to be used for cost and schedule control. He will submit a monthly report of current expenditures and status of work in terms of man-hours and dollars spent versus that budgeted in his project plan. This report will be submitted as a separate document, not as a part of the technical progress report.

5.2.6.1.3 Technical and Management Review Meetings

The subcontractor will provide for technical coordination meetings, as needed but, at least once a month, with TRW Systems representatives for the purpose of reviewing progress, technical, and managerial problems. In general, these meetings will be held at the subcontractor's facility.

5.2.6.1.4 Engineering Development Plan

The subcontractor will prepare an engineering development plan that will serve as the subcontractor's control document for the engineering effort necessary to fulfill the requirements of this SOW. This plan will include, as applicable, the analyses, tradeoff studies, design verification, and evaluation of interface requirements that will be performed to ensure the subcontract item will meet the requirements as specified in this SOW and the applicable equipment specification referenced in paragraph 5.2.5 of this SOW. In the event of conflict between the engineering development plan and this SOW, the SOW shall take precedence.

- Organization and Personnel. The plan will include an organization chart of the engineering group that will perform this effort and a description of their respective responsibilities.

- Schedules. The plan will contain a master engineering schedule that identifies significant events and key decision points. It will relate all phases of engineering design, development, and verification testing, and be compatible with the total project schedule from start of subcontract to delivery of the subcontract items.

- Tasks. The plan will include a definition of all tasks to be performed, including those listed under paragraphs 6.2 (Design and Development) and 6.4 (Testing) of this SOW. The plan will also include a task flow diagram showing all tasks and the interaction and dependency of one task to another. All items on the flow diagram will be numbered for convenience and briefly described. Reference should be made to the paragraph numbers of the engineering development plan and/or SOW to identify the origin of the task requirement.

5.2.6.2 Design and Development

The subcontractor will furnish a design that satisfies the requirements of the instrument specification.

The design and development task includes;

- Design analyses and reviews
- Establishment of detailed equipment and interface requirements which meet the instrument and other applicable specifications
- Electrical, optical, and mechanical design including packaging
- Breadboard construction and test
- Preparation of drawings and test procedures
- Tests and evaluation of engineering model
- Manufacturing and test support
- Interface coordination with TRW
- Test equipment design
- Worst-case analysis.

5.2.6.2.1 <u>Design Requirements</u>

The subcontractor will conduct investigations, evaluations, and analyses to establish and confirm the design parameters for the equipment. The design will include analyses that demonstrate and document adequate performance margins with respect to the requirements of the applicable specifications, including a worst-case analysis based on worst-case conditions and end-of-life degradation. The design will include the establishment of detailed functional characteristics of the equipment including thermal and mechanical stress analyses demonstrating adequate margins with respect to the specified environments.

5.2.6.2.2 <u>Select-In-Test Components</u>

The subcontractor will advise TRW and obtain prior approval for the use of any designs which necessitate select-in-test components required to attain specific performance characteristics. Such designs will be avoided to the greatest extent possible.

5.2.6.2.3 <u>Design Audits/Review</u>

Two formal design audits will be conducted by the subcontractor at his facility with TRW personnel in attendance. Both of these audits will be conducted in accordance with the requirements of paragraph 5.3.5.4;

the data required to conduct these reviews such as design audit notification, design audit data packages, design audit minutes, and design audit close-out document will be preapred as required by Section 5.3 and submitted according to the requirements of Table 5-1.

The preliminary design audit (PDA) will be conducted in accordance with the schedule contained in the program plan.

The critical design audit (CDA) will be conducted immediately following completion of testing and data reduction and analyses of engineering test data. Written approval of the critical design audit will constitute authorization for final design release to fabrication for protoflight and flight units.

5.2.6.3 Engineering Data

The subcontractor will prepare and maintain drawings, specifications, and associated lists to completely define and describe the equipment.

5.2.6.3.1 Drawings

The subcontractor will furnish and maintain a complete set of drawings for all deliverable equipment. The set will include fabrication drawings, assembly drawings, outline and/or installation drawings, functional schematics, interconnection wiring diagrams, interface control drawings, functional block diagrams, and circuit diagrams. Fabrication drawings will include all detailed drawings, control drawings, and assembly drawings used in the end-item manufacturing. Drawings will be prepared in accordance with the requirements of Section 5.3.

5.2.6.3.2 Engineering Data List

The subcontractor will furnish and maintain a list of all drawings, specifications, and parts for all deliverable equipment in accordance with the TRW configuration management section of Section 5.3.

5.2.6.3.3 "As-Built" Parts List

The subcontractor will furnish and maintain an as-built parts list for all deliverable equipment in accordance with the TRW configuration management section of Section 5.3.

5.2.6.3.4 Control Specification

The subcontractor will meet the parts, materials, and processes requirements of Section 5.3.

5.2.6.4 Manufacturing and Delivery

The subcontractor will fabricate, assemble, test and deliver the equipment specified in Table 5-2 of this SOW.

5.2.6.4.1 Manufacturing Plan

The subcontractor will prepare a manufacturing plan that will include:

- Tooling and test equipment requirements
- Fabrication, assembly, inspection, and test flow patterns
- Facilities and equipment required
- Detailed manufacturing schedules
- Material procurement and material flow plan
- Production test plan.

5.2.6.4.2 Manufacturing Services

The subcontractor will provide all necessary manufacturing services such as planning, expediting, coordination, scheduling and others as may be required to meet the requirements of the SOW.

5.2.6.4.3 Interchangeability

The subcontractor will meet the interchangeability requirements of Section 5.3.

5.2.6.4.4 Special Tooling and Test Equipment

The subcontractor will design, manufacture, procure, or otherwise acquire, all necessary tooling and test equipment. Maximum use will be made of suitable existing tooling and test equipment that is currently in the subcontractor's possession.

5.2.6.4.5 Deliverable Test Equipment

The subcontractor will fabricate, assemble, test and deliver the special-purpose deliverable test equipment specified in Table 5-2 of this SOW. As a minimum, the subcontractor will apply the following design criteria and supply the associated technical information listed below for each type of deliverable test equipment.

- The design will be in accordance with the best commercial design practices and Section 5.3. MIL-STD components and devices will be used in the design wherever possible. Commercial devices of industrial quality may be used where no appropriate MIL-STD components exist.

- Inspection of deliverable test equipment will be in accordance with Section 5.3.

- The subcontractor will submit the following documentation in accordance with Table 5-1

  - Drawings and schematics in accordance with the subcontractor's drawing format

  - Bill of material (may be included as part of standard drawing format)

  - Operating manual

  - Calibration procedures

  - Certified test data sheets showing compliance with test equipment performance requirements

  - Unit functional test procedures.

5.2.6.4.6 Packing and Packaging

The subcontractor will provide packing and packaging as specified in the applicable equipment specification except as follows. The shipping container will be durably and legibly marked to provide the following information:

> Item name, subcontractor, subcontractor's serial number, TRW purchase order number, date of manufacture, and part number.

One copy of the shipping instructions and bill of lading will be forwarded to the cognizant subcontract administrator.

5.2.6.5 Testing

The subcontractor will conduct a test program to demonstrate that all specified requirements are satisfied. This program will cover the following: engineering development tests, engineering model tests, qualification tests, and acceptance tests.

5.2.6.5.1 Test Plan

The subcontractor will prepare and submit a test plan to TRW covering all required activities specified in Section 5.2.6.5. The test plan will include at least the following:

- Description of test article and a schematic of test setup
- Description of the tests to be performed including the environmental conditions to be imposed (i.e., general levels, durations, combinations, etc.)
- Test sequence — special note should be made of any critical sequence order that must be followed
- Applicable documents (e.g., specifications and drawings)
- Performance requirements to be met before, during, and after each sequence
- A list of other test equipment/fixtures/facilities required
- Definition of responsibilities between engineering design, reliability, test, quality control, and any other personnel required
- Incorporate, either directly or by reference, calibration procedures for test equipment
- Test schedules.

5.2.6.5.2 Engineering Development Tests

The subcontractor will conduct tests and demonstrations necessary to validate the design approach. These tests will be conducted during the design phase on nondeliverable engineering hardware (breadboard). TRW will have the option of witnessing critical tests and will be notified 7 days in advance of such tests. In addition, as part of the monthly technical progress report the subcontractor will provide summary test data and analyses for all critical breadboard tests.

5.2.6.5.3 Engineering Model Tests

The engineering model will be subjected to tests including, but not limited to, functional and qualification level vibration/thermal cycle tests. These tests will be reported and/or witnessed as described above.

5.2.6.5.3.1 Test Procedure, Engineering Model

The subcontractor will prepare a detailed acceptance test procedure for submission to TRW in accordance with Table 5-1. TRW approval for submission is required prior to its use. This procedure will include at least the following data:

- Test configuration diagram and/or schematics
- Test equipment list including type, range, and accuracy for each item
- Test parameters to be measured
- Acceptable test values and tolerances
- Specific data to be taken
- Test methods
- Test data sheets.

5.2.6.5.3.2 Test Report, Engineering Model

The subcontractor will perform reduction and analysis of the test data and prepare a comprehensive test report using the results of all analyses performed on data obtained during the test. The test report will cover all points included in the approved test procedure and contain, as a minimum, the following information:

- Subcontractor identification
- Subcontract item identification
- Report identification
- Identification of test(s) performed and description of hardware item(s) sufficient to establish exact configuration of the test item
- Narrative analysis of test objectives
- Identification of applicable test procedures and specifications
- Start and completion dates of test
- Copy of all raw test data
- Detailed analyses of test results
- Conclusions and recommendations as a result of test (includes drawings, graphs, tables, photographs, etc., as necessary to support the test)

- Narrative description of analyses of all failures encountered during testing, with particular attention to corrective measures and their bearing on future tests.

5.2.6.5.4 Qualification Tests

The subcontractor will conduct qualification tests on the qualification unit in accordance with the requirements defined in the equipment specification and the approved qualification test procedure. These tests will demonstrate compliance with the specified performance and environmental requirements. The individual tests will be completed without any adjustments or repairs being accomplished on the unit during a test sequence. In the event of failures or modifications after completion of any portion of the qualification test, that portion of the test to be rerun will be determined by TRW. All events indicative of abnormal operation not resulting in failures will be reported in detail.

TRW will witness the qualification tests performed under this SOW. TRW will be notified 2 weeks prior to the commencement of qualification testing.

5.2.6.5.4.1 Qualification Test Procedure

The subcontractor will prepare a detailed qualification test procedure for submission to TRW in accordance with Table 5-1. TRW approval of this procedure is required prior to its use. Contents of the test procedure shall be the same as specified on page 5-18, Test Procedure Engineering Model.

5.2.6.5.4.2 Qualification Test Report

Requirements for the qualification test report are the same as those specified on page 5-18, Test Report Engineering Model.

5.2.6.5.5 Acceptance Tests

The flight unit will be subjected to acceptance tests (environmental and performance) at the subcontractor's facility. TRW will witness these tests and will be notified 7 days in advance of acceptance tests for each unit. Acceptance test requirements are specified in the applicable equipment specification and the tests will be conducted in accordance with approved test procedures.

5.2.6.5.5.1 Acceptance Test Procedure

The subcontractor will provide an acceptance test procedure for the production units for submission to TRW in accordance with Table 5-1. TRW approval of this procedure is required prior to its use. Contents of the test procedure will be as specified on page 5-18, Test Procedure Engineering Model.

5.2.6.5.5.2 Acceptance Test Report

Requirements for the acceptance test report for each deliverable production unit are the same as those specified on page 5-18, Test Report Engineering Model.

5.2.6.6 Mission Assurance

The subcontractor will implement a mission assurance program to meet the requirements of Section 5.3.3. The procedures to be followed to insure delivery of contract items to the mission assurance standards imposed shall be shown in the appropriate mission assurance plans. The data delivery requirements relating to mission assurance are specified in Table 5-1.

5.2.6.6.1 Mission Assurance Program Plan

The subcontractor will prepare a mission assurance plan in accordance with Section 5.3.3.1.

5.2.6.6.2 Configuration Management Program/Plan

The subcontractor will implement a configuration management program that conforms to the requirements of Section 5.3.4.

The subcontractor will prepare a configuration management plan in accordance with the requirements of Section 5.3.4.1.

5.2.6.6.3 Reliability Program/Plan

The subcontractor will comply with the reliability requirements of the applicable equipment specification referenced in paragraph 5.2.5 and with Section 5.3.5.

The subcontractor will prepare a reliability plan in accordance with the requirements of Section 5.3.5.1.

5.2.6.6.4 Parts, Materials, and Processes/Plan

The subcontractor will comply with the parts, materials, and processes (PM&P) requirements of the applicable equipment specification referenced in paragraph 5.2.5 of this SOW and Section 5.3.6.

The subcontractor will prepare a PM&P plan in accordance with Section 5.3.6.1.

5.2.6.6.5 Quality Assurance Program/Plan

The subcontractor will comply with the quality assurance requirements of the applicable equipment specification referenced in Table 5-1 of this SOW and Section 5.3.7.1.

The subcontractor will prepare a quality assurance plan in accordance with Section 5.3.7.1.

5.2.6.6.6 Safety Program/Plan

The subcontractor will comply with the safety requirements of the applicable equipment specification referenced in paragraph 5.2.5 of this SOW and Section 5.3.8.

The subcontractor will prepare a safety plan in accordance with Section 5.3.8.1.

5.3 MISSION ASSURANCE SUBCONTRACTOR REQUIREMENTS

5.3.1 Scope

5.3.1.1 Purpose

The purpose of this document is to establish mission assurance program requirements for subcontractor-furnished hardware that will be used on the program. Mission assurance includes five disciplines:

- Configuration management
- Reliability
- Parts, materials, and processes (PM&P)
- Quality assurance
- Safety

The requirements for each are included in this document.

5.3.1.2 Intent

It is the intent and objective of this document to cause compliance with the overall mission assurance requirements in the most cost-effective manner possible. Substantial cost savings can accrue should the subcontractor propose existing off-the-shelf type component hardware. Therefore, provisions are included within the requirements of this document to take advantage of this potential cost savings without degrading performance, quality, reliability, or safety. New designs will comply with the requirements herein in their entirety unless a waiver is approved by TRW. Modifications of existing designs will be treated as either new or existing, depending on the extent of the modification; the determination of this category will be made by TRW.

5.3.1.3 Off-the-Shelf Hardware

Off-the-shelf hardware is any hardware or equipment that has been designed, tested, and qualified for space use. When proposing such hardware, the subcontractor should provide relative details concerning the program for which it was developed. This data should include, but not be limited to:

- Name of program or project
- Mission constraints
- Environmental requirements
- Qualification/performance/failure history (both on the ground and in orbit).

The subcontractor must comply with the requirements of this document, but in content rather than format. Acceptable previous performance of tasks specified in this document will satisfy the requirements. Tasks not previously performed must be accomplished per the requirements of this document. Unless specifically stated otherwise, the off-the-shelf criteria is applicable to every requirement in this document.

5.3.2 Applicable Documents

The following documents of the exact issue specified form a part of this document to the extent specified herein. In the event of conflict between the documents referenced and other detail contents of this document, the detail requirements herein will be considered superseding.

Military

MIL-STD-100A	Engineering Drawing Practices
MIL-STD-130D	Identification Marking of U.S. Military Property
MIL-STD-454C	Standard General Requirements for Electronic Equipment — Requirement 1 — Safety (Personnel Hazard)
MIL-STD-756A	Reliability Prediction
MIL-STD-889	Dissimilar Metals
MIL-D-1000	Drawing, Engineering and Associated Lists

NASA

NHB 5300.4(1C)	Inspection Systems Provisions for Aeronautical and Space System Materials, Part, Components and Services
NHB 5300.4(3A)	Requirements for Soldering Electrical Connections
50M02442V	Material Control for Contamination due to Outgassing

TRW

TBD	Approved Parts List

5.3.3 Mission Assurance Program Management Requirements

The primary purpose of a mission assurance program is to ensure that equipment is designed, manufactured, tested, and delivered in an acceptable manner. To meet this objective, the subcontractor is required to plan and implement a mission assurance program as an integral part of the design, development, and manufacturing cycle. The program will respond to the requirements of this document.

The mission assurance program proposed by the subcontractor will be an effective and economical program which is planned, integrated, and developed in conjunction with other planning functions. It will be suitable to the type and phase of the development/manufacturing cycle and will be based on such factors as severity of requirements, complexity of design, and manufacturing techniques. Adequate considerations will be given to all aspects of design, development, and manufacture to assure that contractual requirements are met.

5.3.3.1 Mission Assurance Program Plan

The subcontactor will prepare a Mission Assurance Program Plan* describing how he will comply with the requirements of this document. The preliminary version of the plan to be submitted concurrent with the proposal and an updated version submitted 30 days after contract award. The plan must be approved by TRW, and in case of conflict between the plan and the requirements herein, this document shall prevail. The subcontractor will submit any proposed changes in the approved plan to TRW for approval prior to their implementation; and correct any deficiencies in his plan which would preclude his compliance with this document.

For off-the-shelf hardware, existing program plans (generated for that equipment) are acceptable. If this document contains a task or tasks not specified in the existing program plan, the plan should be revised to reflect the new requirement(s).

Organization

The subcontractor will designate one individual who will have the responsibility and authority for directing and managing the mission assurance disciplines (or one individual for each). He (they) will have direct, unimpeded access to the management level having full responsibility for the contract work and will report regularly to this management on the status and adequacy of the disciplines. Specific functional assignments to implement each element of the mission assurance disciplines

*Separate program plans for each mission assurance discipline or logical combinations are acceptable if the subcontractor feels that it would be more cost effective.

will be made. Personnel performing the functions will have sufficiently well-defined responsibility, the organizational authority, and the technical capability to assure compliance to the requirements stated herein.

The program plan will identify the organization(s) and key personnel responsible for managing the mission assurance disciplines, clearly define the responsibilities and functions of those directly associated with policies and implementation, stipulate the authority delegated to the mission assurance organization(s) to enforce its policies, and describe the relationships between line, staff, service, and policy organizations.

Program Control

For each mission assurance discipline, the plan(s) will include but not be limited to:

- A detailed listing of specific tasks and procedures to implement and control the tasks
- A current description of each task
- The method of control to ensure execution of each task as planned
- Designation of milestones with scheduled start and completion dates for each task
- Procedures for recording status of actions to resolve problems
- Methods for dissemination of requirements and of coordination with other interfacing efforts such as design, manufacturing, and test
- Methods for assuring that the activities of the subcontractor's suppliers are consistent with the overall EOS requirements.

5.3.3.2 Program Review and Status Reporting

TRW personnel will periodically audit the subcontractor's facilities to ensure that tasks are being performed in a satisfactory manner. TRW will notify the subcontractor in advance of each audit.

Mission assurance status will be contained in a separate section of the monthly progress report required by the SOW. The status should provide a complete accounting of progress on each applicable mission assurance task.

5.3.4 Configuration Management

This section defines the subcontractor configuration management requirements. All configuration management data delivery requirements are identified in the Subcontractors' Data Requirements List (SDRL) portion of the SOW for subcontractors. In case of conflict between the SDRL and this document, the SDRL shall govern.

5.3.4.1 Configuration Management Plan

The Configuration Management Plan can either be a separate plan or a section within the Mission Assurance Program Plan. To the greatest extent possible, the plan should reflect the subcontractor's existing internal change control procedures.

The subcontractor's plan must provide a system for the identification, control, and accounting of the configuration of his deliverable equipment designed and developed for the project, from the point of its initial definition continuing throughout the life of the contract. In general, the plan should include:

- A technique for establishing and controlling baselines
- A method of preparing engineering drawings, identifying parts on drawings, and re-identifying noninterchangeable items
- Instructions for preparation, control, and maintenance of specifications
- A plan for preparation and maintenance of engineering release records
- A plan for control of interfaces with TRW and other associated contractors
- The establishment of major configuration management milestones
- Instructions for implementation and use of a configuration change control, accounting, and status reporting system
- Control of second-tier suppliers.

A subcontractor who procures items requiring design and development from outside sources for incorporation into equipment deliverable to TRW is responsible for ensuring that these sources are also subject to similar configuration management controls. (Compliance with this requirement is subject to NASA/TRW review.)

5.3.4.2 Configuration Identification

All subcontractor-supplied equipment will be accurately described and identified by engineering drawings and associated lists, and specifications. Inspection records will verify conformance with this documentation. The subcontractor identifies:

- Every level of assembly (from piece part through final deliverable hardware)
- Every item delivered to TRW (including parts, equipment, manuals, computer tapes, card decks, etc.)
- Engineering drawings and associated lists and specifications as approved and formally released by the subcontractor into his release system. (These documents determine the configuration for each item of deliverable equipment.)
- Contracts, purchase orders, or other source documents which establish a technical and management interface between the subcontractor and his suppliers.

5.3.4.2.1 Configuration Identification Numbers

Configuration identification will be accomplished by use of the following types of numbers:

- Manufacturer's code identification numbers
- Specification numbers and revision levels
- Engineering drawing numbers and revision levels
- Part numbers and revision levels
- Serial (or lot) numbers.

5.3.4.2.2 Specifications

The design and development task of the subcontractor will include establishment of detailed equipment and interface requirements which meet TRW equipment and other applicable specifications. He will prepare and maintain detail specifications for all parts, materials, and processes used (except where MIL, NASA, and other specifications are employed) in fabricating the equipment. These specifications will be on file and available for review by TRW upon request.

5.3.4.2.3 Engineering Drawings and Associated Lists

New subcontractor documentation generated for the EOS program — such as engineering drawings, associated lists, drawing formats, and drawing and part identification numbers (including the requirements for the re-identification of noninterchangeable hardware) — will be in accordance with MIL-STD-100. Existing documentation not conforming to MIL-STD-100 will be used as is providing it is legible and suitable for its intended use.

Drawings must satisfy the requirements of MIL-D-1000, Category E (procurement, Identical Items), Form 2 (Drawings to Industry Standards, Partial Military Controls).

All project engineering drawings, changes, and related engineering data submitted to TRW under a subcontract must be of sufficient quality to permit acceptable microfilming. The number of copies and delivery schedule will be specified in the SDRL.

5.3.4.2.4 Interface Documentation

TRW determines major interfaces through its equipment specifications, source and specification control drawings, envelope drawings, etc. The subcontractor's interface documents are his top assembly drawings and his qualification and acceptance test procedures, which are subject to TRW approval.

5.3.4.2.5 Item Identification and Marking

All equipment specified to be delivered in the subcontract will be identified with an identification plate or marking on the equipment in accordance with MIL-STD-130 and the applicable equipment specification.

5.3.4.2.6 Serialization

The subcontractor will assign serial numbers to all deliverable hardware designated by TRW as end items. Selection of serial numbers will be at the subcontractor's option provided that they are assigned in sequence and are continuous without duplication. When lot number control is used, the serial number will be traceable to the production lot number. The subcontractor may serialize any other equipment as may be required for internal control.

5.3.4.2.7 Engineering Release

The subcontractor will maintain engineering release records in accordance with his own internal procedures, systems and formats, and the requirements of this document.

The subcontractor's release system will be capable of determining:

- The composition of any part number at any level in terms of authorized subordinate part numbers
- All next higher using (next assembly) part numbers of any hardware
- The serial numbers of the end item which constitutes the effectivity of any change to the identification number of the serialized equipment or subordinate equipment
- A subcontractor's own procurement specification, or specification or source control drawing number associated with any equipment procured for an outside source.

The release system and documentation will identify engineering changes and retain complete configuration records of equipment which has been formally accepted by TRW.

5.3.4.3 Configuration Change Control

The subcontractor must be able to evaluate, program, price and implement changes to equipment with a minimum reaction time. His change control system must be able to assure that:

- Identification of the equipment configuration at the time of first delivery to TRW is accurate and complete
- Equipment modified by incorporation of noninterchangeable changes (such as those to dimensions, functions, materials and for processes made after first delivery) or changes that affect the scope of the subcontract must be identified by different part numbers for each configuration
- All units of the equipment will be considered when planning incorporation of a noninterchangeable change.

Each engineering change will be assigned the appropriate classification in accordance with the following definitions:

- Class I Engineering Change. A proposed engineering change will be designated as Class I whenever any of the following are affected:

1) Equipment specification (including performance)

Contract price or fee, contract guarantees or incentives, contract delivery, or test schedules

All approved detail design configuration drawings and documentation for flight hardware subsequent to the critical design audit (CDA) hardware manufacturing baseline where the following are affected (as designed)

- Electrical interference to communications, electronic equipment, or electromagnetic radiation hazards
- Configuration of hardware which has been qualified and when requalification testing is required or a change of vendors, substitution, or new source is proposed
- Any change affecting nuclear radiation sources

4) The approved detail design configuration and verification documentation which establishes the product configuration baseline for the equipment (as-built)

At any time that modification of hardware is planned or required to be accomplished outside the subcontractor's prime production facility (as shipped).

- Class II Engineering Change. A proposed engineering change will be designated as Class II when it does not fall within the Class I definition.

  Example of a Class II Engineering Change:

  Engineering changes within the equipment which do not affect the part number at the qualified end item level.

The subcontractor will support two formal design audits which are normally held at his facility. Data packages for preliminary design audit (PDA) and critical design audit (CDA) will be supplied on the schedule stated in the SDRL. He will also support a configuration inspection (CI) to be conducted on the first of each type subcontract flight end item to be presented for TRW acceptance.

5.3.4.3.1 Configuration Control Prior to Critical Design Audit

Prior to successful completion of CDA, changes will be controlled to the requirements section of the TRW equipment specification which will constitute the documentation of the design requirements baseline. The subcontractor will not deviate from this specification without notification and must have TRW approval.

5.3.4.3.2 Configuration Control Subsequent to Critical Design Audit

Subsequent to CDA, the subcontractor will not implement any proposed Class I change without prior approval of the proposed change by TRW. Class II changes will be submitted on the subcontractor's format to TRW for approval of the change classification concurrent with the release of the change by the subcontractor for incorporation into equipment. If TRW disagrees with the assignment of Class II, the subcontractor will be notified within five working days after receipt of the change notification. Successful completion of CDA will constitute the approved product configuration baseline.

5.3.4.3.3 Subcontractor Requested Engineering Changes

To request Class I change approval, the subcontractor will describe the proposed change on an engineering change proposal (ECP), shown in Figure 5-1. The completed ECP accompanied by adequate supporting data will be submitted to TRW for approval by the project configuration control board (CCB). If the change affects a specification, the ECP will be accompanied by a proposed specification change notice (SCN), prepared in accordance with the subcontractor's approved configuration management plan.

If the subcontractor proposes a Class II change and the classification is subsequently disallowed by TRW, it must be cancelled. It may then be reprocessed and resubmitted as a Class I change, and any work commenced under the assumption of a Class II change will be discontinued until approval of the Class I change is received from TRW.

Changes requiring prior TRW approval will be authorized only by an official subcontract change notice. If a change is not approved, TRW will return it to the subcontractor with appropriate direction for its resolution.

5.3.4.3.4 Nonconformance Control

Whenever end items, including subordinate assemblies and parts, are discovered to be nonconforming to the governing configuration identification, this condition will be documented on a supplier information request and processed for TRW's disposition in accordance with the TRW quality assurance requirements (see Section 5.3.7.3).

1 (CONTRACTOR NAME) | ENGINEERING CHANGE PROPOSAL | PCN | DATE | PAGE 1 OF ___

ECP DESIGNATION

2 CONTRACT END ITEM NO. | MFG. CODE | SYS. DESIG. | ECP NO. | SUFFIX | REV.

3 RECOMMENDED PRIORITY ☐ EMERGENCY ☐ URGENT ☐ ROUTINE

4 CONTRACT NO. | CEI NOMENCLATURE | PART OR LOWEST ASSY AFFECTED: PART NO. OR TYPE DESIG. | NAME

5 TITLE OF CHANGE

6 JUSTIFICATION FOR CHANGE (INCLUDE CONSEQUENCE IF NOT INCORPORATED)

☐ REQUESTED ☐ DIRECTED BY PROCURING ACTIVITY PER REF ___________

7 DESCRIPTION OF CHANGE (ALTERNATE SOLUTIONS INCLUDED ☐ YES ☐ NO)

CHANGE CATEGORY ___________

8 DATE BY WHICH CONTRACTUAL AUTHORITY IS NEEDED

9 EFFECTIVITY AND MANDATORY CHANGE PERIODS FOR INCORPORATION

VEHICLE/SITE & CEI SERIAL NO.	CHANGE PERIOD	MOD. KIT DEL DATE	EST M/H FOR MOD. KIT INSTL.	OUT-OF-SERVICE TIME

YES	NO		ENCL	PARA
☐	☐	PREVIOUSLY ISSUED MODIFICATION INSTRUCTIONS AFFECTED (EXPLAIN)	___	___
☐	☐	PROOFING OF MODIFICATION INSTRUCTIONS AND KIT INSTALLATION REQUIRED (EXPLAIN) PROOFING LOCATION ___________	___	___
☐	☐	RETEST REQUIRED (IDENTIFY TEST INVALIDATED BY CHANGE)	___	___
☐	☐	REQUALIFICATION REQUIRED (INCLUDE DESCRIPTION OF TEST PLAN FOR REQUALIFICATION)	___	___

Figure 5-1. Engineering Change Proposal Form

10	(CONTRACTOR)	ECP NO.	SUFFIX	REV	PAGE 2 OF ____

	YES	NO	EFFECT ON ITEM	ENCL	PARA
11	☐	☐	DEVELOPMENT REQUIREMENTS AND STATUS	____	____
	☐	☐	SAFETY	____	____
	☐	☐	RELIABILITY (INCLUDE RELIABILITY DATA SUMMARY SHEET)	____	____
	☐	☐	ORBITAL SERVICE LIFE	____	____
	☐	☐	CONFIGURATION AND VERIFICATION REQUIREMENTS (KSC)	____	____
	☐	☐	TEST/OPERATING PROCEDURES (EXPERIMENT AND SPACECRAFT)	____	____
	☐	☐	MISSION OPERATIONS AND ORBITAL ACTIVATION	____	____
	☐	☐	RADIO FREQUENCY OR ELECTROMAGNETIC INTERFERENCE	____	____
	☐	☐	COMPUTER PROGRAMS (DATA RETRIEVAL AND REDUCTION)	____	____
	☐	☐	ENGINEERING CRITICAL COMPONENTS	____	____
	☐	☐	OTHER ECP'S AFFECTED BY THIS CHANGE	____	____
12	☐	☐	LOGISTICS	____	____
	☐	☐	SPARES (INCLUDE SPARES MODIFICATION PLAN)	____	____
	☐	☐	GFE/GFP/TRAINERS	____	____
	☐	☐	DATA/PUBLICATIONS	____	____
	☐	☐	AGE AND CYCLE CRITICAL COMPONENTS	____	____
13	☐	☐	INTERFACE	____	____
	☐	☐	PRELIMINARY INTERFACE REVISION NOTICES ATTACHED	____	____
			ICD NO. ____ PIRN NO. ____	____	____
			ICD NO. ____ PIRN NO. ____	____	____
			ICD NO. ____ PIRN NO. ____		
	☐	☐	ECP/PIRN COORDINATED WITH ASSOCIATE CONTRACTOR(S) OR MSFC. PROVIDE NAME(S) AND DATES OF INITIATION AND RESULTS OF COORDINATION.	____	____
14			CONTRACT SPECIFICATION AFFECTED	____	____
			SPEC. NO. ____ DWG. NO. ____		
			SPEC. NO. ____ DWG. NO. ____		
			SPEC. NO. ____ DWG. NO. ____		
	☐	☐	TEXT OF SPECIFICATION CHANGED		
	☐	☐	CONTRACT AND SPECIFICATION REQUIREMENTS	____	____
	☐	☐	PERFORMANCE AND SCIENTIFIC CAPABILITY	____	____
	☐	☐	PAYLOAD CAPABILITY (ESTIMATED AND CONTRACTUAL WEIGHT)	____	____
	☐	☐	DELIVERY SCHEDULE (UNDELIVERED ITEMS)	____	____
	☐	☐	OTHER ____	____	____
	☐	☐	SPECIFICATION CHANGE NOTICES ATTACHED		
			SCN NO. ____ SPEC. NO. ____	____	____
			SCN NO. ____ SPEC. NO. ____	____	____
			SCN NO. ____ SPEC. NO. ____	____	____
15			EST TOTAL PROGRAM COSTS AND DETAILED BREAKDOWN ARE PROVIDED IN ENCLOSURE	____	____
16			SUMMARY OF EFFECT OF PROPOSED AND PREVIOUSLY APPROVED CHANGES ON MAJOR END ITEM	____	____
17					

Figure 5-1. Engineering Change Proposal Form (Continued)

5.3.4.4 Configuration Accounting

To assure effective logistics support, the subcontractor's configuration accounting system must be capable of maintaining and verifying the configuration status of all equipment for which he has design responsibility.

As specified in the SDRL, the subcontractor furnishes to TRW all information required for the engineering data list. This list will be in the subcontractor's own format, but indentured, top assembly down, to the lowest detail part.

As part of each serialized end item delivery, the subcontractor will submit an "as built" parts list showing the assembly indenture breakdown for each end item delivered. Each list must identify all hardware making up the end item being supplied by part number, part name, and serial number, if applicable, to the detail piece part level. In addition, the list must include all applicable specification numbers. When certified by the subcontractor's quality assurance organization, this list will constitute the "as built" verification report.

5.3.5 Reliability

This section defines the subcontractor reliability requirements. All data delivery requirements are summarized in the SDRL.

5.3.5.1 Reliability Analysis

The subcontractor will perform reliability analyses to determine compliance with the numerical reliability requirements listed in the equipment specification. The analyses will take account of the equipment operating cycles, mission time, and environmental factors such as operating and survival temperatures, shock, vibration, etc. They will include, but not be limited to:

- A brief description of the operation of the equipment
- A reliability mathematical model and block diagram
- A schematic diagram

The emphasis of such analyses will be on guiding the design toward a meaningful balance among such parameters as performance, reliability, weight, cost, etc. The reliability modeling, predictions, and assessments will be performed in close coordination with the failure modes and effects analysis.

Predictions will be performed using the methods of MIL-STD-756A or TRW-approved alternates. Generic parts failure rates are listed in Table 5-3, supporting rationale and data will be submitted to TRW for approval. Mathematical treatments will be presented in sufficient detail to make the analysis technique clear. A detailed reliability prediction will be submitted with the design data package for the preliminary design audit. This prediction will be updated and submitted with the critical design audit, design data package.

For off-the-shelf hardware, the subcontractor will submit with his proposal existing analyses adjusted for the EOS mission time. Updated analyses will only be required for design changes and to correct deficiencies.

Use of TRW generic failure rates in reliability math modeling and tradeoff calculations is encouraged, but the subcontractor will additionally examine circuits for overstressed parts and make appropriate design changes.

5.3.5.2 Failure Modes and Effects Analyses

The subcontractor will perform a failure modes and effects analysis (FMEA) on his hardware to determine possible modes of failure causing the end item to fail to perform its intended functions or meet fail-safe requirements as defined in the equipment specification. The FMEA should concentrate on those parts which interface with or influence a unit's redundant counterpart (and whose failure could negate the intended redundancy), or interface with other units in the spacecraft.

The subcontractor will identify single failure points in the design and eliminate the cause of such failures wherever practical. When it appears impractical to eliminate single-point failure modes, the subcontractor will describe the design steps required to eliminate the single-point failure and why it is considered impractical to change the design.

Table 5-3. Generic Part Failure Rates and Failure Mode Distribution

Part Type	Failure Rate/10^9 Hours (25% Rated Stress 30°C Ambient Temperature)	Failure Mode Short (%)	Failure Mode Open (%)
Capacitors			
Ceramic, feedthrough, filter	12	50	50
Ceramic, fixed	1	50	50
Tantalum, foil	22	60	40
Tantalum, solid	9	85	15
Tantalum, wet slug, glass sealed	8	60	40
Glass, fixed	3	60	40
Mica, fixed, dipped, or molded	2	60	40
Mica, fixed, button	23	60	40
Mylar, fixed	27	60	40
Plastic, fixed	4	60	40
Ceramic, variable	22	60	40
Glass, variable	44	60	40
Air, variable	125	60	40
Connectors			
General	10+1/active pin		
Coaxial	10		
Diodes			
Silicon, general	0.8	60	40
Silicon, switching	0.8	60	40
Silicon, tunnel	100	60	40
Silicon, varactor	79	60	40
Silicon, zener	15	60	40
Silicon, power	26	75	25
Germanium	13	60	40
SCR	45	80	20
Microwave	51	60	40
Integrated Circuits			
Digital, bipolar, <12 gates/chip (RTL, DTL, TTL)	20	60	40
Digital, bipolar, 12 to 100 gates/chip (MSI)	120	60	40
Digital, bipolar, >100 gates/chip (LSI)	220	60	40
Digital, MOS, <12 gates/chip (SSI)	50	60	40
Digital, MOS, 12 to 100 gates/chip (MSI)	100	60	40
Digital, MOS, >100 gates/chip (LSI)	150	60	40
Analog	203	60	40
Hybrid	(Sum of component element failure rate but not less than 500)	60	40
Magnetics			
Inductor, RF coil	14	20	80
Magnetic amplifier	32	20	80
Choke	4	20	80
Transformer, RF	17	40	60
Transformer, ≤100 volts	18	40	60
Transformer, >100 volts	56	50	50
Transformer, pulse	10	40	60
Transformer, audio	12	40	60
Relays			
General, multiple cycle application	59		
Latching, multiple cycle application	52		
Redundancy switching only	5		
Resistors			
Carbon composition	2		
Metal film	0.1	0	100
Wirewound, fixed	15	0	100
Wirewound, variable	50	10	90
Transistors			
Silicon, ≤5 watts	4	60	40
Silicon, >5 watts	50	60	40
Silicon, switching	13	60	40
Field effect	100	60	40
Germanium	257	60	40

Table 5-3. Generic Part Failure Rates and Failure Mode Distribution (Continued)

Part Type	Failure Rate/10^9 Hours (25% Rated Stress 30°C Ambient Temperature)	Failure Mode Short (%)	Failure Mode Open (%)
Miscellaneous Electrical Components			
Battery cells	80		
Crystals, quartz	20		
Fuses	100		
Heater	10		
Motors	10		
Slip rings	860/brush		
Solar cell	0.2		
Switch	11		
Thermistors	105		
Thermostats	70		
Microwave Components			
Filters (low pass)	(sum of component element failure rates)		
Hybrid	(sum of component element failure rates)		
Coupler	(sum of component element failure rates)		
Ferrite junction	5		
Stripline structure	1		
Variable attenuators	80		
Waveguide	(sum of component element failure rates)		
Tuning screw	0.5		
Waveguide flange	0.1		
Mechanical and Propulsion Components			
Accumulator	5		
Antenna	20		
Bearings	11		
Bladder	330		
Conditioner	5		
	50 (cycles)		
Damper	500		
Expansion joints	2		
Explosive nut	300,000		
Filter	1		
Gas generator	50		
	100 (cycles)		
Heater exchanger	5		
	50 (cycles)		
Hinge assembly	100		
Latch mechanism	20		
Liquid acquisition device	5		
Nozzle, hot gas	166 (cycles)		
Nozzle, cold gas	17 (cycles)		
Pin puller	300,000 (cycles)		
Regulator	562		
	2411 (cycles)		
Springs, tension	20		
Springs, compression	10		
Squib	300,000 (cycles)		
Switch, pressure	320		
	80 (cycles)		
Tank	5		
Transducer, pressure	540		
Valve, check	2		
	700 (cycles)		
Valve, explosive (NC)	900,000 (cycles)		
Valve, explosive (NO)	1,900,000 (cycles)		
Valve, fill	56		
Valve, manual	5		
Valve, relief	10		
	1,000 (cycles)		
Valve, solenoid	56		
	299 (cycles)		

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A summary of the FMEA results will be submitted initially with the preliminary design audit data package; the updated summary will be submitted with the critical design audit data package. The detailed analyses will be retained in the subcontractor's files and will be available for TRW review.

Based on the results of the FMEA, the subcontractor will compile a listing of the more critical hardware within his equipment. This critical items list (CIL) will be used as a basis for selectively imposing more stringent management and quality control, and will include single failure points and critical/redundant backup components.

For off-the-shelf hardware, the subcontractor will submit (with his proposal) existing FMEA's and CIL's performed for the previous program. Updated analyses will only be required for design changes and to correct deficiencies. Updated analyses may be performed using either the previous format or the EOS format.

5.3.5.3 Design Review

The subcontractor will schedule and conduct two formal design reviews:

- Preliminary Design Audit (PDA). To be held after circuit design and breadboard testing are complete (after initial design and engineering model testing for mechanical, structural, and propulsion equipment). The primary purpose of the PDA is to ensure that the subcontractor fully understands the requirements of the equipment specification and has optimized his design approach to meet these requirements.

- Critical Design Audit (CDA). To be held when development indicates that the design will meet the requirements. The primary purpose of the CDA is to ensure that the subcontractor's design is ready to be released to manufacturing. No drawing release to production may be made until approval is given by TRW.

The design will be reviewed for both adequacy of conceptual approach and feasibility of reducing design concepts to hardware. The reviews will cover interfaces, parts, materials, processes, electrical, mechanical and thermal considerations. Existing failure histories will be reviewed for adequacy of corrective actions to eliminate repetition of known failures.

A single review will be held for off-the-shelf designs to validate the acceptability of the existing design to the EOS requirements.

5.3.5.3.1 Notification/Data Required

The TRW subcontract administrator will be notified 3 weeks in advance of both the PDA and CDA. Two weeks prior to each meeting, both meeting notices/agendas and design data packages will be delivered to TRW. Data package requirements for both the PDA and CDA are given in Table 5-4.

5.3.5.3.2 Meeting Conduct/Documentation

TRW will co-chair the meeting and cognizant TRW personnel will participate on the review committee. The subcontractor will employ his own review committee and supply the technical secretary.

The subcontractor will submit meeting minutes to TRW for approval within 7 days of the meeting, and publish the approved minutes 2 weeks following the meeting. As a minimum, the meeting minutes will contain:

- Attendance at meeting
- Action item, agreement, and alert summaries with sufficient detail to be self-explanatory
- Statement of approval status of the design by the co-chairmen.

The subcontractor will submit a closeout document to TRW for approval no later than 30 days following the completion of each meeting. As a minimum, the closeout document will contain:

- Meeting notice/agenda
- Meeting minutes
- Responses to all action items
- Statement by design review co-chairmen concerning approval of design.

5.3.5.4 Subcontractor Control

The subcontractor will implement a program and associated procedures for assuring that his suppliers' reliability procedures are consistent with overall program requirements, and provide adequate surveillance of the suppliers' product assurance activities including failure

Table 5-4. Design Data Package Requirements

	PDA	CDA
Summary		
1. Requirements		
• Applicable documents	F	C
• Design status and table comparing requirements versus capabilities	F	C
2. Table of major interfaces — electrical, functional, and mechanical, including power requirements	F	C
Engineering Description		
1. Block diagram, layouts and/or circuit schematic, and functional description	P	F
2. Parts, materials, and processes lists	P	F
3. Engineering drawings and applicable change orders	P	F
Test		
1. Test plans and requirements	P	F
2. Qualification and acceptance test procedures		F
3. Test data and test reports (formal and informal)	S	S
Analyses		
1. Performance analyses	P	F
2. Thermal design; mechanical design, worst case analysis	P	F
3. Reliability	P	F
• FMEA and reliability prediction	P	F
• Parts stress versus capability		F
• Failures-to-date with analysis and corrective action		S
4. Tradeoffs (if applicable)	S	S
Packaging		
1. Special design considerations	P	F
2. Method of construction and finishes	P	F
Manufacturing and Quality Assurance		
1. Manufacturing flow diagram	P	F
2. Fabrication and Inspection procedures	P	F
3. Tool drawings and test procedures	P	F

Key

S Current Status
F Final Data
P Preliminary Data
C Changes

reporting. The surveillance will include but not be limited to such items as maintaining a supplier selection program based upon review of the supplier's reliability program, quality control system, examination of their facilities, and past performance to ensure that suppliers are capable of attaining and maintaining the required level of reliability. Requirements of the subcontractor's reliability program will be imposed on suppliers of subcontractor critical items unless waiver of specific requirement is approved by TRW.

5.3.5.5 Failure Control System

The subcontractor will implement a formal and controlled system for reporting, analysis, corrective action, and data feedback of all failures and malfunctions which occur during testing of deliverable equipment. This system emphasizes reporting, analysis, and corrective action, as applicable, of all failures and malfunctions regardless of their apparent magnitude.

The subcontractor will submit, as part of his reliability plan, sample copies of his failure reporting, failure analysis, and corrective action formats.

5.3.5.5.1 Failure Reporting

The subcontractor will document all failures by providing information to adequately describe the failed equipment, the operation in progress, the conditions of failure, the symptoms of failure, the action taken at the time of failure, the probable causes, and possible methods of corrective action. The subcontractor will notify TRW within 24 hours after each failure occurs and a copy of the failure report received by TRW within 7 days after the occurrence of failure.

5.3.5.5.2 Failure Analysis

The subcontractor will analyze all failures after the start of acceptance testing of deliverable equipment to determine the cause of each failure. All electrical and electronic part failures (excluding repetitious failure causes determined by previous analysis) require failure analysis. The failure analysis format will reference the failure report and include a brief description of the cause or causes and the identification of the facility performing the analysis. The analysis will be performed or concurred with by the organization responsible for the implementation of corrective action.

5.3.5.5.3 Failure Analysis of Returned Equipment

The subcontractor will analyze failed equipment returned by TRW in the same manner as above. If the analysis reveals the failure to be caused by external factors after delivery to TRW, the subcontractor is to make recommendations for recurrence prevention. If the analysis reveals causes under the control of the subcontractor or his suppliers, the subcontractor will implement corrective action.

5.3.5.5.4 Failure Review

The subcontractor may be required to participate in the TRW Failure Review Board (FRB) meetings, depending on the magnitude and seriousness of the failures. TRW will notify the subcontractor in writing at least 24 hours in advance.

5.3.5.6 Operating Time Logs/Limited Life List

The subcontractor will report to TRW accumulated operating time and/or cycles on the end item equipment and any cyclic or life critical hardware. Electrical operating time and mechanical cycle totals must be separately documented and the documentation shipped with the equipment.

The subcontractor will also submit a list of equipment having critically limited useful lives. This limited life list is to be submitted with the proposal for off-the-shelf hardware, or for new designs, with the PDA data package or the parts, materials, and processes list required by Section 5.3.6.

5.3.5.7 Test Equipment

The subcontractor will design all test equipment in such a manner that a failure of the test equipment cannot propagate to the flight hardware, thereby causing damage. Test connectors mating with the flight hardware must be flight-qualified parts meeting the requirements of Section 6 of this document. Maximum use should be made of connector savers during testing to avoid undue wear and connector/pin damage.

The subcontractor will design deliverable test equipment in accordance with the best commercial design practices using MIL-STD parts and devices whenever possible. Commercial parts and devices of industrial quality may be used where no appropriate MIL-STD part or device exists.

5.3.6 Parts, Materials, and Processes

This section defines the subcontractor parts, materials, and processes (PM&P) requirements. All data delivery requirements are summarized in the SDRL.

5.3.6.1 Parts Tasks

5.3.6.1.1 Parts Selection

The subcontractor will use parts listed in the TRW-supplied program approved parts list (PAPL) wherever possible, make every effort to standardize on the parts required, and minimize the number of parts used. When use of a PAPL or first order preference part is not possible, the subcontractor will submit request with justification to obtain TRW approval for use of the part. The request will contain as a minimum:

- Subcontractor part number
- Closest generic equivalent part number
- Part usage (quantity and circuit application)
- Reliability data
- Justification for use
- Applicable use history
- Proposed supplier(s)
- Reason(s) that a PAPL or first order preference part cannot be used.

5.3.6.1.2 Part Specifications

Each part will be procured to a controlling specification. This specification may be existing or the subcontractor may have to prepare a new specification. In either case, the specification must be approved by TRW and must contain screening, qualification, and control requirements. Part testing may be accomplished at the part supplier or by an outside testing laboratory approved by TRW.

5.3.6.1.3 Part Qualification

Part qualification will be the responsibility of the subcontractor and all parts used will be qualified to the environmental levels expected (with margin or levels commensurate with related military specification limits for similar part types, whichever is more severe). Maximum use should be made of qualification data from other similar applications. When qualification testing is required it may be accomplished by the part supplier or by an outside testing laboratory approved by TRW.

5.3.6.1.4 Parts List

The subcontractor will maintain a parts list that identifies the qualification status of each part.

5.3.6.1.5 Parts Application Review

The subcontractor will conduct a parts application review. Parts will be applied in accordance with derating criteria to be specified.

5.3.6.1.6 Response to Suspect Parts Notices (Alert Support)

The subcontractor will establish procedures to respond to notices of suspect parts and/or specification deficiencies forwarded to him by TRW. Information is to be furnished to TRW on the use of suspect parts, including location and usage in the subcontractor's equipment and the effect failure would have on the equipment. The subcontractor traceability system will provide the methodology to locate specific supplier lots so that further analysis and corrective action may be performed when such action is found to be necessary. The subcontractor will report detected deficiencies and resulting corrective action.

5.3.6.1.7 Receiving Inspection

The subcontractor will accomplish receiving inspection in accordance with procedures to be specified.

5.3.6.1.8 Off-the-Shelf Hardware

If the subcontractor proposes to use off-the-shelf equipment, only the following parts tasks apply:

- The subcontractor is to submit his parts list with the initial proposal. Any redesign will be considered a new design and parts handled accordingly.
- The subcontractor will submit with his initial proposal screening information which identifies the level of screen accomplished on the various part types.

5.3.6.2 Materials and Processes (M&P) Tasks

5.3.6.2.1 Materials and Processes Selection

The subcontractor will select materials on the basis of suitability for their application(s) and proven qualification to the requirements of the applicable specification. The potential for arc production, flammability, and outgassing characteristics of all materials will be considered. All materials and processes selections will require approval by TRW. The subcontractor is to submit a list of all materials and processes which are anticipated for use in the design to TRW. The following criteria will be considered by TRW in judging acceptability of the materials and processes:

- Suitability for use in the intended application
- Consistency with contractual requirements as set forth in the equipment specification
- Adequacy of control documentation and consistency with selection criteria defined in the equipment specification
- Adequacy of testing/data criteria to verify suitability.

5.3.6.2.2 Materials and Processes Specifications

All materials and processes will be defined by standards and specifications. Subcontractors are to select standards and specifications from government, industry, and company specifications and standards in accordance with the following:

- NASA specifications and standards
- MSFC specifications and standards

- Other NASA center specifications and standards
- Federal specifications and standards
- Military specifications and standards
- Other governmental specifications
- Specifications released by nationally recognized associations
- Contractor specifications.

Rationale for the selection of subcontractor specifications and standards over existing higher order of precedence standards and specifications will be compiled and maintained for historical record and made available to TRW upon request.

5.3.6.2.3 Materials and Processes Qualifications

Materials and processes qualification will consist of the following steps:

- TRW survey of subcontractor's facilities and approval of adequacy
- Review and approval of the material's design applications by TRW specialist (engineering drawing review)
- Review and approval of applicable controlling materials and processes specifications (subcontractor materials and processes list)
- Verification of material outgassing, dusting, corrosion, cleanliness, and fungus characteristics
- Final qualification testing and acceptance of the hardware as required in the applicable governing equipment specification.

5.3.6.2.4 Materials and Processes List

The subcontractor will list all materials and processes and the documentation controlling their procurement and/or application for the equipment being supplied. This list is to include full identification of:

- Material or process
- Manufacturer
- Manufacturer's description

- General description
- Procurement or process specification number
- Qualification status
- Intended application or usage.

Documentation (procedures, manufacturing shop orders, etc.) used to implement processes will be provided to TRW for review. This list is to be updated periodically to reflect related changes in the design configuration. The material and process list will be submitted to TRW for review and subject to individual item disapproval revision(s) only in case of updates every 30 days unless no changes occur.

5.3.7 Quality Assurance Requirements

5.3.7.1 General

The subcontractor shall establish and maintain an efficient and cost effective quality assurance system in accordance with the intent of NASA publication NHB 5300.4(1C), Inspection System Provisions for Aeronautical and Space System Materials, Parts, Components and Services and the amendments to NHB 5300.4(1C) specified herein. The system shall:

1) Be consistent with the complexity of the manufacturing techniques required to produce the assembly.

2) Ensure the performance of inspection of hardware, both manufactured and produced, for conformance with procurement requirements and produce evidence of this accomplishment. This system shall function in conjunction with the subcontractor's other systems of materiel, manufacturing, testing, etc.

3) Provide a method for rejecting and segregating hardware not conforming to applicable specifications to prevent its unauthorized use in the end item.

4) Provide a means for detecting repetitive hardware discrepancies and instituting appropriate corrective action to preclude recurrence. This system shall cover the subcontractor-manufactured hardware as well as material received from his suppliers.

In addition to the requirements of this document, the subcontractor shall meet the requirements of the supplemental clauses, TRW Systems Form 1991, Supplier Quality Attachment 1 to SQI 3.03, Revision 11-72, as specified in the subcontract Statement of Work. TRW Systems Group will assign resident or itinerant Quality Assurance personnel to the subcontractor's facility during performance of the subcontract. The subcontractor must, during the regular business hours, or at such other time as may be necessary, permit such Quality Assurance personnel access to his facilities for determination of compliance with this document and must furnish without cost to TRW Systems Group such facilities and services which may reasonably be required in support thereof. A list of duties, responsibilities, and authority of the assigned Quality representative is provided in Appendix C.

TRW Systems Group Quality Assurance reserves the right to interpret the extent to which this document applies on equipment and services for each subcontract.

The subcontractor shall include as a part of his monthly project status report, a summary of quality program status. This information shall include but not be limited to the following:

1) Technical progress and status of the quality tasks listing significant accomplishments.

2) Identification of significant quality problems and resolutions or corrective action planned.

3) Quality events/milestones scheduled for the next reporting period.

5.3.7.2 Amendments to NHB 5300.4(1C)

5.3.7.2.1 Inspection System Plan (Para. 1C 201)

A TRW Systems quality system survey and thorough review of the subcontractor's Quality Assurance Manual will be performed prior to award of the subcontract. Based on acceptable survey results and implementation of adequate remedial measures to correct any noted deficiencies, inspection plan for this subcontract will not be required. TRW assurance that the quality aspects of the subcontract are being met will be verified by a TRW source representative (Reference Para. 1.1.3).

5.3.7.2.2 Procurement Controls (Para. 1C 300)

The subcontractor shall maintain a list of approved suppliers (sources) and continually review and evaluate the supplier's quality system. When special processes are required to be performed by a supplier, the subcontractor shall ensure that these processes comply with the requirements specified in the subcontract from TRW.

5.3.7.2.3 Inspection and Test Records (Para. 1C 305)

An end-item inspection and test report (acceptance data package) shall be prepared and transmitted with the subcontract end-item and shall include the following:

- End-item configuration list
- End-item nonconformance record
- Copy of end-item acceptance test reports or procedures which include weight, variables test data and results.
- List of critical and time/temperature sensitive articles
- Operating time/cycle record of component and/or subsystem, where applicable.

When TRW Source Inspection is assigned to the subcontractors facility, TRW source verification of equipment acceptability must be in evidence on the appropriate documentation prior to shipment of the material.

5.3.7.2.4 Process Controls (Para. 1C 307)

TRW Systems reserves the right to review the subcontractor's control of special processes for adequacy during the life of the subcontract. The subcontractor's detailed process control procedures and certification records of equipment and personnel shall be available for audit when requested by the TRW source representative. The subcontractor shall be responsible for establishing and maintaining the necessary controls to prevent contamination of components and assemblies during hardware fabrication, assembly, test inspection, handling, packing and storage.

All soldering performed on this subcontract shall be consistent with the requirements of NHB 5300.4(3A), "Requirements for Soldered Electrical Connections".

5.3.2.7.5 Nonconforming Article and Material Controls (Para. 1C 309)

If a major subcontractor to TRW has design cognizance, he may request authority to establish a formal Material Review Board for purposes of making dispositions on materials or products on which variations exist. Deviations can only be dispositioned by TRW by a subcontractor request for waiver.

For purposes of this document, variations and deviations are defined as follows:

- Variations: Any nonconformance to drawing or specification requirements which, in the opinion of TRW Systems Group Quality Assurance, does not adversely affect safety, weight, interchangeability, service life, reliability or performance.

- Deviation: Any nonconformance to drawing or specification requirements which, in the opinion of TRW Systems Group Quality Assurance, does adversely affect safety, weight, interchangeability, service life, reliability, performance, or the basic requirements of the contract.

5.3.7.2.5 Variation, Material Review Authority

If a major subcontractor wishes to request variation material review authority from TRW Systems Group, he must submit to TRW Systems Group Quality Assurance, via TRW Systems Group Material, complete documentation of the proposed Material Review Board organization and the governing policy. This documentation must include:

- Organization chart(s) showing the line authority of all proposed Engineering and Quality personnel involved.

- Copies of proposed detailed operating procedures.

- Copies of all proposed forms, tags, etc., and a description of their usage.

- Complete description of the cause investigation and corrective action system the supplier proposes to use to prevent the recurrence of all discrepancies that the proposed Board will review.

When deviations arise, the subcontractor may contact the cognizant buyer for authorization to submit a Supplier Information Request (SIR Form 2212) for TRW Systems Group evaluation and disposition. The subcontractor will be notified of the SIR's disposition.

5.3.7.2.6 Metrology Controls (Para. 1C 310)

The subcontractor shall maintain standard policies and practices for assurance and control, calibration, evaluation, and maintenance of inspection, test and measuring equipment in accordance with MIL-C-45662. The subcontractor's inspection system shall ensure that all inspection and test equipment used to determine acceptance of project hardware is currently calibrated and within limits established by specifications.

5.3.7.2.7 Sampling Inspection (Para. 1C 311)

Sampling inspection shall be allowed when the articles to be sampled are considered noncritical. When sampling is employed, as in receiving inspection of certain procured materials to verify compliance with procurement requirements, the sampling plan used shall be in accordance with existing military standards.

5.3.7.2.8 Documentation Submittal Schedule

Item	Para.	Submittal Due
1. Quality Status Report	1.1.4	Monthly
2. Acceptance Data Package	1.2.3	With item shipment
3. SIR, Supplier Information Request	1.2.5	As required

5.3.8 Safety

This section defines the general subcontractor safety requirements. Specific safety requirements applicable to each subcontractor are contained in the equipment specification. Data delivery requirements for safety requirements are identified in the SDRL.

5.3.8.1 Safety Plan

The safety plan can either be a separate plan or a section within the Mission Assurance Program Plan. The plan is to indicate the methods by which the subcontractor will comply with both the general and specific safety requirements.

5.3.8.2 Definitions

Safety Terms

- Accident, Type A. A mishap, including fires, causing a death and/or disabling injury to five or more persons and/or damage to equipment or property including program hardware exceeding $100,000.

- Accident, Type B. A mishap, including fires, causing disabling injury to four or fewer persons and/or damage to equipment or property including program hardware exceeding $10,000, but less than that of a Type A accident.

- Incident. A mishap, including fires, of less than accident severity to personnel or property (i.e., less than Type A or B); specifically, where injury to personnel results in no lost time beyond that day of the mishap and/or where damage to equipment or property including program hardware, including damage by fire, is less than $10,000 and greater than $250. A near-miss occurrence, which might have resulted in an accident, is also considered an incident.

- Personnel Hazard. The presence of a potential risk situation caused by an unsafe act or condition resulting in the chance of injury to personnel (e.g., noise, vibration, explosion, fire, air pollution, and radiological release).

- Accident Prevention. Methods and procedures used to eliminate the causes which lead, or could lead, to an accident.

- Fail Safe. The capability of the primary system to fail without being dangerous to other equipment or personnel.

- Risk. The chance of injury to personnel or loss of equipment or property.

- Safety. Freedom from chance of injury or loss to personnel, equipment, or property.

- Shatter. Action of material coming apart in two or more pieces and being dispersed.

- System Hazard. The presence of a potential risk situation caused by an unsafe act or condition resulting in the chance of hardware damage or system loss (e.g., failure to analyze manufacturing, transportation, maintenance, operating and test procedures to assure that they contain proper safety notes, warnings and back-out capability; failure to determine that personnel are qualified to perform certain tasks; failure of equipment that could cause damage to other systems).

- System Safety. The optimum degree of risk management within the constraints of operational effectiveness, time and cost attained through the application of management and engineering principles throughout all phases of a program (i.e., design, test operations, post-flight analysis, etc.).

- Hazard Analysis. The logical process of determining potential sources of danger, and recommending resolutions for those conditions found in either the hardware/software systems, the man-machine relationship, or both, which could cause an undesired event. Supporting data for the hazard analyses may be derived from parametric studies, logic and flow diagram analyses, ground and flight testing, failure mode and effects analyses, engineering analyses, simulations, malfunction and emergency procedure analyses, either individually or in combination.

- Hazards List. A list of personnel hazards and systems hazards identified by the hazards analysis.

- Program Critical Mishap or Problem. An event involving critical program hardware or activities which may cause requirement for additional funding and/or may cause irrecoverable schedule slippage. The event may be an accident or incident as defined above, a development problem such as a hardware or system test failure or a management problem such as a labor strike.

Hazard Categories

Identified system hazardous conditions are categorized as follows:

- Safety Catastrophic. Conditions of environment, personnel error, design characteristics, procedural deficiencies, or hardware malfunction which could cause death or multiple injuries to personnel, or mission loss (spacecraft or at least two experiments).

- Safety Critical. Conditions of environment, personnel error, design characteristics, procedural deficiencies, or hardware malfunction which could cause personnel injury, or equipment damage resulting in loss of one experiment, degraded spacecraft performance, or launch scrub.

- Safety Marginal. Conditions of environment, personnel error, design characteristics, procedural deficiencies, or hardware malfunction which could cause equipment damage resulting in major degradation of one experiment (loss of at least 50 percent of data), or launch delay.

5.3.8.3 System Safety Program Requirements

The following paragraphs establish the requirements for subcontractor system safety program conduct as a part of the engineering effort expended in design, development, and delivery of subcontractor-furnished equipment for the program. In the application of these requirements, care is to be exercised to avoid redundant effort between technical disciplines. Effort will be directed toward accomplishment of the necessary system safety tasks as an integrated part of the subcontractor's engineering effort.

Program Magnitude

The subcontractor will ensure inherent safety through the implementation of appropriate design features (i.e., reliability, redundancy, fail safe design, and appropriate safety factors). An evaluation of all pertinent engineering analyses, tests, and reports (e.g., failure mode and effects analyses, test reports, single failure point summaries, stress analyses) will be made and additional effort implemented as necessary to ensure that an optimum degree of safety is achieved in the equipment design.

Where available for existing designs, safety plans, hazards analyses, etc., may be supplied in their existing form and format.

Compliance Demonstration

The subcontractor will support TRW's safety review of end item design, tests, procedures, etc. Review will normally be accomplished during scheduled equipment design audits (PDA and CDA).

The subcontractor will maintain on file all safety data developed for EOS, whether delivered or not, and make such data available for review by representatives of TRW.

Rationale for all safety related tradeoffs, design decisions, and requirement satisfaction will be documented.

Resolution of all identified safety problems will be achieved prior to delivery of an end item to TRW.

System Safety Audits

TRW will audit subcontractor conformance to applicable safety requirements. These audits will evaluate the degree of conformance to the established safety requirements for design, manufacturing, test, and operational phases. Normally, these audits will be accomplished in conjunction with scheduled design audits; however, TRW reserves the right to visit the subcontractor's facility upon prior notification. The subcontractor will supply requested data to NASA representatives and hold their facilities open to NASA surveillance upon request through TRW. The subcontractor will support these audits.

Interim technical interchange meetings may be held as required to identify design areas of concern, resolve questions, and provide direction regarding safety relevant matters.

Mishap Investigation and Reporting

In the event of a mishap involving injuries or fatalities to personnel and/or property damage to flight or program hardware, or facilities owned by the government or provided as part of a contract or exists for the primary purpose of supporting a contract, each subcontractor will be responsible for the following requirements:

- Provide necessary medical services, fire equipment, and personnel.
- Secure the scene of the accident and take necessary steps to preserve evidence and essential records and obtain names and locations of witnesses.
- If the mishap is a program critical mishap, immediately notify the TRW contracting officer or his technical representative. The notification will include:
  - A concise statement of the problem including essential background if available
  - Assessment of impact on the program
  - Action which has been taken
  - Possible corrective action.

  Complete the investigation, preparation of the report and follow-up. The form shown in Figure 5-2, or an equivalent, is to be provided.
- Support and/or perform accident investigation. Mishap reports will conform to requirements outlined below.
- Implement corrective/preventive action and follow-up on all mishaps.

In the event of a mishap other than a program critical mishap, submit an accident/incident report form to the TRW contracting officer within

ACCIDENT

TO:

TIME AND DATE OF ACCIDENT — HOUR | DAY | MONTH | YEAR

REPORTING UNIT

2. TYPE OF ACCIDENT

TYPE OF ACCIDENT	ON POST	OFF POST
A. NASA AIRCRAFT		
B. NASA MOTOR VEHICLE		
C. NON-NASA MOTOR VEH		
D. NASA FIRE		
E. OTHER		

1. EXACT LOCATION OF ACCIDENT

OR ____ MILES-DIRECTION FROM: ☐ LIMITS OF ☐ CENTER OF ____ TOWN OR CITY AND STATE

3\. a MILITARY, b CIVILIAN EMPLOYEE, c CONTRACTOR, d NON-NASA, e OPERATOR, f PASSENGER, g PEDESTRIAN-OTHER

PERSONNEL INVOLVED
(Military: Name, Grade, Service Number, Unit Assignment)
(Civilian: Name, CS Grade, Job Title, Home Address)

h AGE

EXTENT OF INJURY: i FIRST-AID OR NONE, j TEMP. TOTAL, k PERM. IMPAIR., l FATAL

4\. OWNERSHIP: a NASA, b OTHER GOVT, c CONT. KTOR, d OTHER

EQUIPMENT OR PROPERTY INVOLVED
(Describe aircraft by type, model, series, serial number; structure by size, type of construction; vehicle and other equipment by make, model, year, body type, etc.)

DAMAGES *(Estimated)*
e.

$

$

$

$

5\. DESCRIPTION OF ACCIDENT *(In narrative form, everything that is known about the accident. Include events or conditions which led up to the accident, everything that may have contributed to it, and failures of persons or equipment, supervisory failures, unfamiliarity with operation, errors of judgment, and mission. A complete story.)*

REPORT NO.

CODE

REPORT RECORDED ON
☐ DRIVERS RECORD
☐ CROSS REFERENCED WITH 201

Figure 5-2. Accident/Incident Report Form

6. DIAGRAM OF ACCIDENT *(Indicate vehicles, aircraft, persons, railroad tracks, signs, direction of travel before and after the accident by appropriate symbols. Indicate North by arrow in following circle*

7. ACCIDENT ANALYSIS

a. PRIMARY UNSAFE ACT *(And by whom)*

b. UNSAFE PHYSICAL CONDITION *(Or mechanical or material failure)* IF ANY

c. CONTRIBUTING FACTORS

8. CORRECTIVE ACTION

a. ACTION TAKEN TO PREVENT FURTHER SIMILAR ACCIDENTS

b. RECOMMENDED FURTHER ACTION *(And by whom)*

9. REPORT PREPARED BY *(Supervisor, Investigation Board, etc.)*

10. STATEMENT OF REVIEWING OFFICIAL *(Whether corrective action is considered adequate to prevent recurrence, recommended action by higher authority, etc.)*

DATE	SIGNATURE

11. APPROVED

DATE	SIGNATURE

Figure 5-2. Accident/Incident Report Form (Continued)

5 days after the mishap has occurred. Reporting of minor injuries is not required. (Regardless of monetary value of loss, or type or seriousness of injury, notify the TRW contracting officer of any mishap or unusual occurrence when deemed appropriate.)

In the event of a program critical mishap for a Type A or B accident:

- Notify the TRW contracting officer, his technical representative, or the mission assurance manager by telephone.
- Upon notification by TRW of the occurrence of a mishap or accident, the NASA/MSFC safety director, in conjunction with the appropriate center management, program/project manager, and contracting officer, will determine whether NASA, TRW or the subcontractor will investigate the accident. In general, when NASA interest of involvement is substantial, a NASA board will investigate.
- When NASA implements the investigation, the NASA/MSFC safety director, in conjunction with the appropriate program/project manager will:
  - In the event of a Type A accident, in conjunction with the center director, have an investigation board appointed.
  - In the event of a Type B accident, have an investigating official or board appointed.

Safety of Government-Furnished Equipment (GFE)

Where the equipment includes hardware furnished by NASA, the subcontractor may request, from TRW, NASA safety data on these items. Where examination of these data or testing by the subcontractor indicates inconsistency of the safety of GFE with the safety requirements of the equipment, the procuring NASA installation and TRW will be formally and promptly notified for appropriate action.

Interface with Other Program Functions

Every effort will be made to minimize duplication of tasks. The safety program is to be coordinated and integrated with the other program functions to avoid overlaps and duplication between technical disciplines such as systems engineering, quality, reliability, parts, materials and processes, and configuration management. This coordination will include the delineation of responsibilities, management structure, joint analyses, reporting procedures, feedback of testing data and corrective actions, use of failure mode and effects analyses, critical items lists, or other analytical techniques to identify hazards.

Industrial Safety and Public Safety

The safety program will be compatible with the requirements of the safety and health article of the contract and will include coordination with the subcontractor's routine industrial and public safety efforts to ensure an effective and integrated total safety effort.

5.3.8.4 General System Safety Design Criteria

This paragraph contains general safety design criteria having applicability to virtually all subcontractor-furnished equipment to be employed in the program. Adherence to these criteria will, in most cases, be achieved by compliance with detailed equipment specifications. They are highlighted herein to illustrate the nature of requirements having safety impact. In the event of conflict between these criteria and the equipment specification, the equipment specification will take precedence.

Spacecraft Electrical/Electronic Equipment

- Design of electrical/electronic equipment will be such that it will not be possible to ignite or contribute to the ignition of adjacent materials regardless of the operational atmosphere.
- Electrical/electronic materials, as installed in the system/subsystem and under service conditions specified in the specific equipment specification, will not liberate gases which combine with the atmosphere to form toxic, corrosive fumes.
- The planning and design of wire, cable and harness routing will allow easy access to adjacent equipment connectors in order to permit ease of engaging and disengaging without causing pin short, cable connector damage, or injury to personnel coupling/decoupling connections.
- Connectors on a single piece of equipment which allow mismating because of symmetrical pin design will be eliminated.
- Connectors will be designed with the power side on the female end.
- Critical circuits will be isolated where necessary to prevent degradation or signal faults being induced by adjacent circuits, which would result in an undesired event during the system/subsystem life cycle.

- Electrical shielding will be used wherever radio frequency or other sources of spurious energy can create interference problems in safety critical circuits.

- Supports will be provided to prevent abrasion or chafing of wires or cables which could result in personnel shock or equipment shorts.

- Means will be provided to isolate all power from specific equipment items to allow maintenance or removal operations without shock hazard.

- Elements of redundant systems will not be routed on adjacent connector pins.

- Positive protection in the design will be provided for connectors and conductors to minimize the possibility of short circuits resulting from debris or elements of the environment.

- A means will be provided for positive verification of the states of safety critical circuits.

- Positive protection will be provided against the issuance of inadvertent signals or discretes controlling safety critical functions (i.e., ordnance activation, propulsion system activation, etc.).

- A means will be provided to establish control of equipment discretes and states during start-up, shut-downs, and inadvertent power application or interruption.

- All equipment which permits personnel access during energized periods will conform to requirements of MIL-STD-454C, Requirement 1.

Support Equipment (SE)

- Support equipment (test equipment) circuits interfacing with the hardware will be employed only after initial reliability and safety studies indicate reasonable freedom from hazard. No failure within the support equipment will be capable of propagating to the flight hardware.

- Protective devices will be used to provide circuit and equipment overload protection in powered circuits.

- Interlocks, shielding, safety guards, barriers, and warning markings will be used where personnel hazards exist.

- Common ground terminal to each support equipment console (cabinets or drawer) will be provided for ground strap connection between consoles, hardware, and facility ground.

- All electrical connectors will be coded and/or keyed to prevent mechanical mismatching. Test connectors mating with the flight hardware must be flight qualified parts.

- Electromagnetic interference filters will be used on the primary power circuits and where necessary to reduce conducted noise in keeping with electromagnetic compatibility requirements.

- All equipment which permits personnel access during energized periods will conform to MIL-STD-454C, Requirement 1.

Materials Selection

- Materials selected will be physically and chemically stable under all conditions of service and shall be compatible with all working and test fluids, gases, etc., to which they may be exposed.

- Usage of materials posing a potential toxicological hazard shall be avoided wherever possible. Identification of all potentially toxic materials or byproducts of possible reaction in the specified working environment will be made.

- Particular care will be given to selection of materials to minimize the possibility of stress corrosion. This is especially critical in the design of pressurized systems.

- Usage of materials which pose a fire hazard or can support combustion will be excluded from use.

- Usage of shatterable or frangible parts or devices will be avoided. Identification and characteristics of all such items are to be provided to TRW. System design will furnish protection to such hardware during all specified test and operational environments.

Residual Hazards

Residual hazards for which safety or warning devices and special procedures cannot be developed or provided for counteracting the hazard, will be identified to TRW. Continuation of effort to eliminate or reduce such hazards will be accomplished throughout the program by maintaining awareness of new safety technology or devices being developed and their application to the residual hazards. Rationale for acceptance of residual hazards will be documented.

APPENDIX A

TEMPERATURE/ELECTRICAL STRESS RELIABILITY ANALYSIS PROCEDURE

1. PURPOSE

The basic purpose of performing a temperature/electrical stress reliability analysis (TESRA) is to identify parts which exceed the project derating requirements, and to provide temperature and stress adjusted failure rates for use in reliability predictions. Since the preliminary predictions are usually based on part failure rates for operation at 30 °C and 25 percent electrical stress, they are only a rough approximation of the reliability of the system. The use of the adjusted failure rates obtained from a TESRA analysis reflect a realistic representation of the part actual operating conditions and thus result in a more accurate value of predicted reliability.

2. PROCEDURE

The procedure by which the temperature/electrical stress reliability predictions are performed is shown in Figure A-1 and outlined below:

1) Temperature/Stress Data Calculations

   a) Identify each subassembly of the hardware.

      NOTE: The hardware does not necessarily have to be broken down by subassemblies. It can be done by circuits, functions, outputs, etc., or even left as an end item with no breakdown.

   b) List each piece-part, identifying its rated circuit parameters, such as rating on power dissipation, voltage, etc.

   c) Calculate the electrical stress and temperature of each piece-part.

The pertinent stress information on three major items (semiconductors, resistors, and capacitors) are:

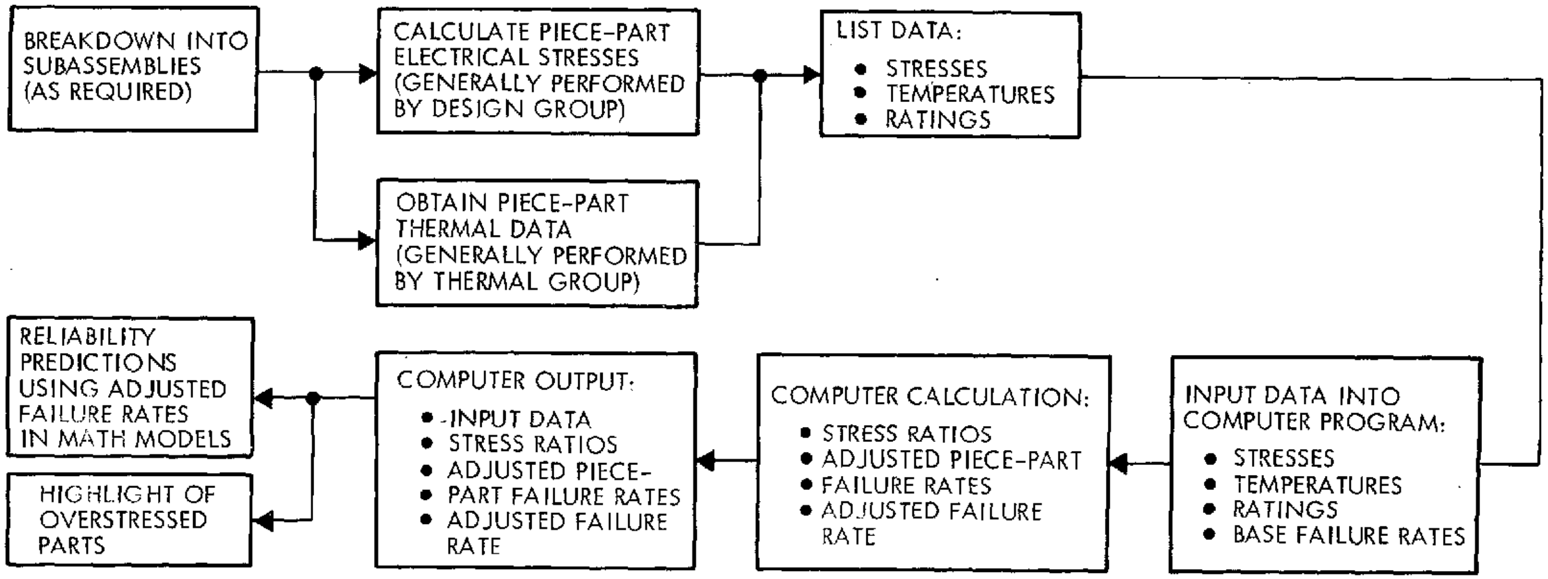

Figure A-1. Temperature/Electrical Stress Reliability Analysis (TERSA) Flow Diagram

ITEM		STRESS
Semiconductors (Either Group 1 or Group 2 is applicable)	1	The operating junction temperature (°C)
	2	• The case temperature (°C) • The thermal resistance between the juction and case (°C/watt) • The power dissipated by the device
Resistors		Average power dissipation at its use temperature and the case temperature
Capacitors		Average applied voltage at its use temperature and the case temperature

2) Computer program to calculate stress ratios and temperature/stress adjusted failure rates.

a) Input data into the computer. The data consists of primarily of:

- Each piece-part and its associated ratings, temperature value and stress value
- The base failure rates at 25 percent electrical stress, 30°C temperature

b) The computer calculates stress ratios for each piece-part

c) The computer calculates temperature/stress adjusted failure rates for each piece-part.

3) Temperature/Stress Reliability Analysis

a) Any stress ratio from step 2b which exceeds the program derating requirements is highlighted as an overstressed part.

b) The failure rates from step 2c are used in place of the previous base failure rates and input into the same math models to calculate the new reliability predictions.

APPENDIX B

TRW

SUPPLIER QUALITY REQUIREMENTS
FORM 1991
ATTACHMENT I SQI 3.0.3

The Quality Assurance clauses contained herein, when specified on Purchase Orders/Subcontracts (P.O./S), shall apply to and become a part of the conditions of the P.O./S. Unless otherwise indicated herein, the term Seller includes Sellers sub-tier suppliers.

Q-1 GENERAL QUALITY ASSURANCE REQUIREMENTS

All of the following paragraphs are applicable to Clause Q-1.

1.0 TRW SURVEYS, SURVEILLANCE, AND INSPECTION

1.1 TRW has the right to conduct surveys and surveillance of the Seller's facility to evaluate the degree of capability, and the continuing application of such ability, to comply with the requirements of this order. This function may also apply, with the Seller's cognizance, to sub-tier suppliers.

1.2 TRW has the right to perform inspection at the Seller's facility during the period of manufacture, inspection prior to shipment and final inspection and acceptance at TRW's plant unless otherwise specified on the P.O./S. After meeting the requirements of the initial receiving inspection, and after final acceptance by TRW, such supplies will be subjected to continued testing and measurement at all levels in order to demonstrate compliance to all applicable requirements. Any supplies determined to be nonconforming may be returned to the Seller for replacement, repair, modification, or otherwise as determined by TRW in accordance with the provisions of this order.

1.3 TRW shall not be obligated to perform complete inspection on nonconforming supplies. Unless otherwise authorized in writing by TRW, the Seller shall furnish TRW only articles which are in complete compliance with all Contract requirements.

2.0 GOVERNMENT SOURCE INSPECTION

2.1 The Government has the right to inspect any or all of the work included in this order at the Seller's plant or at sub-tier supplier's plant.

3.0 MEASURING AND TEST EQUIPMENT

3.1 The Seller shall be responsible for providing and ascertaining accuracy and stability of tools, gages and test equipment to assure that supplies conform to contractual requirements.

3.2 A written schedule shall be maintained to provide for periodic inspection and to assure calibration to adequate standards. Objective evidence of such inspections and calibrations shall be recorded and made available for TRW Quality Assurance review when requested.

4.0 NONCONFORMING MATERIAL

4.1 Unless specifically authorized by the P.O./S, authority to perform "salvage repair" or "use as is" material review decisions on nonconformances discovered at the Seller's facility is retained by TRW. When it is not feasible for the Seller to replace or rework nonconforming material to the P.O./S, drawing or specification requirements, and TRW has authorized shipment of such nonconforming materials, the shipment must be accompanied by documentation showing the following:

A. TRW authorization to ship nonconforming material.

B. Description and cause of nonconformance.

C. Action taken to prevent recurrence.

D. Effectivity of action taken or planned.

4.2 The Seller shall provide for control, segregation and/or identification of nonconforming material discovered at the supplier's facility.

5.0 RESUBMISSION OF REJECTED MATERIAL

5.1 Material failing to meet TRW contractual requirements and returned to the Seller shall not subsequently be resubmitted to TRW without replacement or rework. In the event Seller's reinspection does not verify the reason for rejection, the Seller shall coordinate with TRW Quality Assurance through the TRW Buyer before returning the material in question. Parts resubmitted shall be segregated and tagged "reworked" or "replaced" parts as applicable. In addition, the Seller's shipping document shall bear reference to the TRW nonconforming document and shall contain, or be accompanied by, a written statement indicating the cause for rejection, action taken to provide correction and action taken or planned to prevent recurrence.

6.0 SELLER CORRECTIVE ACTION

6.1 If the Seller is not performing in accordance with contractual requirements, the Seller (upon notification from TRW) shall be required to take corrective action. A formal report shall be made to the TRW Buyer by the Seller, within fifteen days from date of notification, showing evidence of corrective action taken. Said corrective action will be reviewed by TRW and the Seller promptly advised of concurrence or non-concurrence with the corrective action proposed.

7.0 MATERIAL CONTROL

7.1 Material shall be identified and controlled from its receipt at the Seller's facility through delivery to TRW. A method of stamping the material and/or tags or routing cards is the preferred means of identification and control to be used by inspection and test personnel.

Perishable items or those with limited shelf life must be handled/preserved in accordance with recommendations of the manufacturer.

8.0 PACKAGING AND PRESERVATION

8.1 The Seller shall control all preservation, packaging, packing, shipping, and handling to assure that all materials are adequately protected during all phases of P.O./S performance and to assure compliance with any special handling and shipping requirements of the P.O./S.

9.0 INSPECTION RECORDS

9.1 The Seller shall maintain adequate records of all inspections and tests performed for the time specified in the P.O./S. These records shall indicate discrepancies found and information regarding corrective action taken by the Seller and shall be made available to TRW upon request.

Q-2 SELLER'S QUALITY PROGRAM REQUIREMENTS (NHB 5300.4(1B))

The Seller shall, in the performance of this order, provide and maintain a quality program which is in conformance with NASA Quality Publication NHB 5300.4(1B), "Quality Program Provisions for Aeronautical and Space System Contractors".

Q-3 SELLER'S QUALITY PROGRAM REQUIREMENTS (MIL-Q-9858A)

The Seller shall, in the performance of this order, provide and maintain a quality program which is in conformance with Military Specification: MIL-Q-9858A, "Quality Program Requirements".

Q-4 INSPECTION SYSTEM PROVISIONS (NHB 5300.4(1C)) FORMERLY NPC 200-3

The Seller shall, in the performance of this order, provide and maintain an inspection system which is in conformance with NASA Quality Publication NHB 5300.4(1C), "Inspection Systems Provisions for Aeronautical and Space System Materials, Parts, Components, and Services".

Q-5 INSPECTION SYSTEMS REQUIREMENTS (MIL-I-45208)

The Seller shall, in the performance of this order, provide and maintain an inspection system which is in conformance with Military Specification: MIL-I-45208, "Inspection Systems Requirements".

Q-6 TRW SOURCE INSPECTION

TRW inspection is required and must be performed at the Seller's facility prior to shipment. The Seller shall provide all reasonable inspection/test facilities for the TRW representative to verify contract conformance. TRW reserves the right to inspect during the period of performance at Seller's facility and at Seller's source those supplies and services not manufactured within the Seller's facilities. The Seller shall notify the TRW Buyer not less than two (2) working days prior to the need for TRW inspection/test.

After TRW source inspection acceptance, any removal or replacement of components or other rework, including any non-scheduled entry such as removal of a panel, cover, or enclosure, (break of inspection) to gain access or to perform any work or test, will void the source inspection acceptance. In case of any such "break of inspection" TRW shall be notified in order that source inspection can be rescheduled.

Q-7 TRW IN-PROCESS INSPECTION

Supplies on this order will be inspected by TRW during manufacture at:

a. Prior to encapsulation

b. Prior to cleaning

c. Prior to plating

d. Prior to assembly close-up

e. Points specified by the P.O./S

The Seller shall notify the TRW Buyer not less than two (2) working days in advance that the items are ready for such TRW inspection.

After TRW source inspection acceptance, any removal or replacement of components or other rework, including any non-scheduled entry such as removal of a panel, cover, or enclosure, (break of inspection) to gain access or to perform any work or test, will void the source inspection acceptance. In case of any such "break of inspection" TRW shall be notified in order that source inspection can be rescheduled.

Q-8 SUPPLIER FIRST ARTICLE INSPECTION

First article inspection shall be conducted by the Seller on all TRW designed parts, assemblies, forging, and foundry supplied castings. First article inspection reports shall include results of dimensional measurements and, when applicable, results of mechanical tests and nondestructive test inspections. Such reports must also accompany the first unit submitted to TRW after each drawing change, or after any change which affects tooling or molds.

Q-9 GOVERNMENT SOURCE INSPECTION OPTIONAL INSPECTION AGENCY (NASA)

All work on this order is subject to inspection and test by the Government at any time and place. The Government quality representative who has been delegated NASA Quality Assurance functions on this procurement shall be notified immediately upon receipt of this order. The Government representative shall also be notified 48 hours in advance of the time articles or materials are ready for inspection or test.

Q-10 GOVERNMENT SOURCE INSPECTION (DOD)

Government inspection is required prior to shipment from your plant. Upon receipt of this order, promptly notify the Government representative who normally services your plant so that appropriate planning for Government inspection can be accomplished. In the event that the Representative or office cannot be located, the TRW Buyer should be notified immediately.

Q-11 TECHNICAL DATA

Technical information describing all of the items on this P.O./S must accompany the first shipment of any items. This information will be acceptable in the form of catalog sheets or other published documents containing identification, markings, physical dimensions, functional characteristics, typical test data or other pertinent information upon which receiving inspection can be based. The information should reference the applicable P.O./S number and be attached to the packing slip or be enclosed in a separate envelope addressed to TRW Receiving Inspection.

Q-12 TEST REPORTS, PERFORMANCE/ACCEPTANCE TESTS

Two copies of test reports and/or test data recorded during performance/acceptance test, showing evidence of supplier inspection verification, shall accompany each shipment of hardware.

Q-13 TEST REPORTS, PHYSICAL AND/OR CHEMICAL

Physical and/or chemical test reports related to the raw stock used on this order shall accompany each shipment of supplies to TRW. Physical and/or chemical test reports shall indicate, for the purposes of quality analysis, the percentage of each element that makes up the chemical composition and physical properties of all raw materials. The report must specifically identify the material by reference to the mill melt, cast, heat, drop, lot, serial number, or other similar identification, and must identify the applicable specification, revision and TRW P.O./S designation..

Q-14 CASTINGS FOUNDRY CONTROL

The castings on this order require evidence of foundry control. Radiographic film, identified as foundry control X-rays, must be submitted to TRW with sample castings for TRW approval. X-rays must be identified with the TRW order number and will be retained by TRW. Identification must be as specified by the TRW specification or P.O./S.

Q-15 PROCESS CONTROL

The Seller shall assure that special processes, when specified by TRW drawing or specification, are accomplished by TRW certified sources. Documented evidence identifying the certified source must be included with shipment of supplies to TRW. Special processes are defined as welding, brazing, soldering, structural adhesive bonding, heat treating, plating, chemical surface treatment, casting, magnetic particle, dye penetrant and X-ray.

Q-16 TEST DATA IDENTIFICATION

Where Group A, B, or C testing and test data submittal is a requirement of this P.O./S, such data shall be identified with:

a. TRW P.O./S number.

b. Part number.

c. Type of test performed.

d. Serial numbers, lot numbers, or date codes of the lots tested.

e. Total quantity tested and quantity rejected.

f. Serial numbers, lot numbers, and/or date codes, as applicable, of the items on the shipment.

Q-17 PROCESSING AND FABRICATION OF TITANIUM

Records of all processing and fabrication operations performed on titanium alloys shall be traceable to the mill heat number of the raw material and/or TRW purchase order if TRW furnished material is used.

Q-18 RADIOGRAPHIC INSPECTION

The material on this P.O./S requires radiographic inspection by a TRW approved X-Ray Laboratory. Each radiograph shall include the image of the part number, part serial number, identification of the area radiographed, and identification of the view direction. Seller's techniques are subject to prior approval by TRW. Films shall be interpreted by the Laboratory and findings reported on an appropriate form. A copy of the Laboratory report, the radiographic technique, the radiographic sketch and the radiographs shall accompany the material.

Q-19 DRAWING CONTROL

The Seller's Quality Assurance System shall assure that obsolete engineering, manufacturing and/or inspection documentation is removed and replaced at the proper points of effectivity indicated by replacement documentation.

Q-20 CHANGES

The Seller is required to notify TRW of any proposed changes in design, fabrication methods, or processes previously approved by TRW, including changes which may effect the quality or intended end use of the item, and obtain written approval of the change from TRW before making the change.

APPENDIX C

QUALITY ASSURANCE REPRESENTATIVE RESPONSIBILITIES

The duties, responsibilities and authority of the assigned TRW Quality representative are as follows:

- Conduct audits to ensure that the subcontractor maintains a reliability and quality system that meets contractual requirements.
- Conduct a continuous planned review of all phases of the approved quality system to ensure compliance. If deficiencies are found, the subcontractor will be requested to take corrective action.
- Assist the subcontractor in obtaining interpretation of contractual reliability/quality, drawing, and specification requirements.
- Develop quality planning inspection instructions (QPII) in coordination with the responsible engineer.
- Conduct progressive inspection and planned inspection of components, assemblies, and processes as deemed necessary to determine that the products meet the quality and engineering requirements of the subcontract.
- Participate in scheduled design reviews and verify accountability inspection to ensure the incorporation of engineering changes, planning changes, and other configuration change commitments.
- Verify test setup compliance to test plans and procedures, witness tests performed, and verify failure reporting and analysis of test acceptance.
- Review material review disposition when the subcontractor is delegated MR authority; assist the subcontractor in obtaining materials review action on discrepant article if the subcontractor has not been delegated materials review authority.
- Coordinate reports of unsatisfactory conditions received on the subcontractors articles to ascertain that the subcontractor establishes the cause of such discrepancies and takes prompt and complete corrective action; ensure that the corrective action effectivity points are met and maintained to preclude recurrence.

- Assist the subcontractor in the implementation of any interchangeability and replaceability program as defined by the subcontract; witness the inspection and check interchangeability verification.

- Accept and stamp the articles and related paperwork approved for shipment. The subcontractor will be notified of all such articles requiring this operation by the Quality representative.